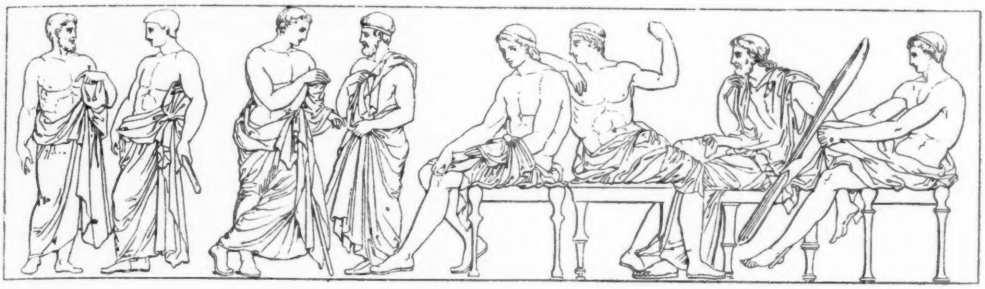

THE USE AND ABUSE OF MARBLE FOR DECORATIVE PURPOSES.

By Professor AITCHISON [F.], A.R.A., WILLIAM YOUNG [F.], and W. BRINDLEY, F.G.S.

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I. By Professor AITCHISON, A.R.A.

STONES are classed in common parlance as precious stones, fine stones, marble stones and common stones. Of late years we have generally dropped the word stone after marble, but I cannot exactly tell you when it was dropped. Chaucer uses the words "marble-stoon" and "marbul-stones," and, as you will see hereafter, Philemon Holland uses "marble stone," and his *Pliny* was published in 1634.

The word "marble" is of Greek origin, and means a stone that is white and glistening. For the ordinary purposes of life, all stones that are not fine or precious and will take a high polish are called marbles, whatever be their constituents, whether they be of aqueous or of igneous origin. Thus, we class porphyry, granite, serpentine, and silicious stones as marbles, as well as the hard carbonates of lime; although there is some hesitation in classing as a marble any opaque-looking stone, in spite of its taking a high polish, such, for instance, as Hopton Wood or Istrian.

Marble has many great qualities. Much of it is very strong, and is found in immense masses, so that monolithic shafts and obelisks can be quarried from it. Some sorts can be worked almost to the fineness and precision of metal, and a large proportion of the coloured varieties, including black and white, are beautiful.

It will, perhaps, show more humanity if the undoubted advantages and merits of marble be first spoken about; for, though we cannot pass over its faults and drawbacks, we can at least give it this advantage: we can first enlarge on its great qualities and general good behaviour, so as to create a bias in its favour, before we set out its disadvantages and shortcomings.

The Greeks seemingly chose marble mainly on account of the perfection to which it could be worked, and the delicate modelling it would express; and the Italians followed in their footsteps. I have seen a marble Renaissance medallion, of the full face of a man, on a chimney-piece at the Ducal Palace, Venice, whose greatest relief is about $\frac{1}{16}$ inch. But, setting sculpture aside, I may say that some of the annulets at the Propylæum still show the sharp and vigorous shadows they were meant to produce, almost as perfectly as they could have done when they were first made, more than two thousand years ago; and this merit is not to be overlooked. As far as the structural workmanship is concerned, Beulé said that the temples on the Acropolis were put together like a piece of cabinet-work. Polished white marble has, too, this great charm, you seem to see into its substance; and the Athenians

were lucky in having mountains of white marble close at hand. The only coloured marble used at the Acropolis is the black marble of Eleusis at the Propylæum.

It is, however, to the Romans we must look for the first development of a strongly pronounced taste for coloured and variegated marbles. Monsieur Charles Garnier says of the Romans :—" They sent discoverers of quarries from all parts; they excavated mountains; they " destroyed plains. Every discovery became the occasion of a public festival. Every new " marble had the honours of a triumph, and when a bed furnished a block of extraordinary " size they made a column of it; they erected it in a public square, and gave it up to the " admiration of the multitude."

The introduction of marble into Rome, except for temples, was at first looked on with great disfavour. M. Brutus called L. Crassus " the Palatine Venus," because he had some small marble columns in his house; and the elder Pliny was very indignant at people running risks and quarrying mountains, for the fashionable Romans to have their bedrooms lined with variegated marbles; and he inveighs against the invention of veneering. Philemon Holland's translation of this passage of Pliny is quaint enough to give :—" For as yet I do not reade or " find by any sign, that Italy knew how to slit marble into leaves. But surely, whosoever " devised that invention, to saw marble stone, and to slit it into leaves for to serve the turne of " riotous and wastful persons, had a perillous head of his own, and a shrewd " (Pliny, *Nat. Hist.* xxxvi. 6. F.). Though before Pliny's time the use of marble was comparatively common, as we learn from Horace and others, while Augustus and Tiberius had a passion for the serpentines of Egypt. The pontoon that brought over the obelisk in the days of Claudius was used for the foundation of one side of his harbour at Ostia; and from some porphyry statues being presented to him, porphyry was called Claudian marble (*marmor Claudianum*). The younger Pliny did not share his uncle's horror of marble, for he tells us in his letters that at his Tuscan villa the dado of one of his rooms was of carved marble. He had an alcove in another room supported by four cipollino columns, and a summer-house of exquisite marble.

Eventually every country in the known world, not to speak of the Roman dominions, was ransacked for marble, and the Roman quarries became the property of the emperors; and doubtless a large revenue was raised by farming them. To show that it was not the Roman dominions alone that produced the marble they used, I may say that Corsi found at Rome a rare yellowish marble of no beauty, called Astracan, which has only been found in India, near Agra. The great Roman general Lucullus gave his name to a plain blackish marble called by the Italians Bigio Morato, mulberry grey, that he had brought from the island of Melas in the Nile, and this marble was called Lucullean. Another Roman, since his death, has given his name to a marble—the breccia of Septimius Bassus, from its having been found at his villa. The Italians call it Breccia de Sette Basi, which amused the late William Burges, who said it meant a marble of seven bases, so he bought a piece, and had it worked, and put it in the hall of his house at Melbury Road.

It is difficult for us to realise the enormous quantity of precious marbles used by the Romans, even when we picture to ourselves the marbles of Rome since transported to various countries; those that have been cut up for pavements, for slabs, vases, and articles of *virtu*, not to speak of the lime they have furnished; but we can form some idea from our reading. The country house of the Gordiani in one single portico had two hundred columns, fifty of Carystian, fifty of Claudian, and fifty of Numidian marble; in the same villa were three basilicas having a hundred columns each. The poets of the silver age were sufficiently interested in marbles to give us accounts of their colour and beauty. Statius, who lived in the first century, celebrated the Baths of Etruscus, and speaks of the Giallo Antico, and even mentions the blood-red veins of the pavonazzetto of Phrygia; while Martial speaks of the

onyx, the green porphyry, and the serpentine, as well as the Giallo Antico and the pavonazzetto of the same baths (Martial, *Epig.*, vi. 42); and Paul, the Silentiary, wrote a poem in Greek, on the marbles used at St. Sophia.

Faustino Corsi, a Roman barrister, became an enthusiast on the subject of ancient marbles, and devoted a good part of his life to identifying the marbles mentioned in the Roman writers, with those found at Rome, and wrote a book on the subject.* He had good-sized specimens squared and polished; these he sold to a former Duke of Devonshire, who presented them to the University of Oxford; by the kindness of Sir H. Acland they were brought out into the light and dusted for me to see. Corsi's own private collection, composed of small pieces about an inch square set in two slabs of marble, is at the Geological Museum, Jermyn Street.

I have said so much of the Roman use of marble, because all through the Dark Ages and up to Mediæval days the greater part of the marbles used were taken from Rome or from Roman buildings. Justinian got the columns and slabs for St. Sophia from all parts of the Roman dominions. Abd-el-Rahman is said to have got most of the capitals and columns of his mosque at Cordova from Roman buildings or their ruins in Spain, and as presents from the French king. Charlemagne got permission from the Pope to plunder Ravenna for his palace at Aix-la-Chapelle. Some of the early Popes are said to have destroyed more Roman buildings for their churches than the Goths, the Huns, and the Vandals. In Renaissance days the marbles still left at Rome were used for churches and palaces by the Popes and great people, or were given away to potentates. The column in the Piazza della Justizia at Florence came from Caracalla's Baths. Should an epoch of wealth ever occur again, and the rich spend large sums on rare marbles, the blocks of marble at the Marmoratum may be dug up and used.

Since the taking of Algeria and Tunisia by the French, the quarries of Numidia have been re-opened, so that many of the marbles formerly called "Antique," to show that the quarries were unknown, are antique no longer—the Giallo Antico, for example. The quarries of the Rosso Antico, the Carystian, the Verde Antico, the green porphyry of Taenarium, and other Greek marbles have been rediscovered. Mr. Brindley has also found the old Docimenian, Synnadic, or Phrygian quarries, as well as the granite, porphyry, oriental alabaster, and serpentine quarries in Egypt; while new quarries have been opened in America and in various other parts of the world.

The great drawback to the use of flowered marble for columns that bear weight, except the cost, is its liability to flaws and defects, and there is nothing to be done but to have the shafts tried by the hydraulic press before using them. Granite and porphyry were preferred by the Romans for heavily laden columns of large size, as we see at the portico of the Pantheon, and inside Santa Maria degli Angeli; while white marble, Giallo Antico, Carystian, Phrygian, Grechetto duro, and occasionally Verde Antico and, they say, oriental alabaster were used for smaller columns, such as those inside the Pantheon, and to the Temple of Antoninus and Faustina.

There is not much objection to the internal use of marble in England, except that it looks and feels cold in winter; and when buildings are not warmed the marble condenses the damp. The marbles mainly formed of carbonate of lime are worse than useless when employed outside; the polish rapidly perishes, and so far from their looking, as Monsieur Garnier says, "like shabby gentlemen," they look like sweeps. The only objection to the proper use of marble is lest the more beautiful and costly sorts may usurp the place of statuary (which is bronze figure-work), pictures, and sculpture.

In old work we see, not only the sumptuousness of marble, but the harmonising hand of time. In a smokeless atmosphere, even when marble crumbles, as it does with the sea air at Venice, there is a preciousness about the tints that is charming. In speaking of marble used

* *Delle pietre antichi.* By Faustino Corsi, Romano. Third edition. 8o. Rome, 1845.

outside, and of the perishing of its face, Monsieur Garnier says:—" Do not fear too much this " softening effect; if marble allows some of its brilliance to be veiled in the open air, it always " preserves its peculiar aspect; its tints are seen, its texture shows itself, and the firmness of its " substance is preserved; it is no longer marble coloured and resplendent, but it is always " marble—that is to say, it is refinement, elegance, and harmony. It shows its origin, " distinguishes itself from other materials as a tatter of silk is always distinguishable from a " tatter of cloth." But I beg you to observe that he speaks of the atmosphere of Paris.

The use of marble for decoration is to colour harmoniously by means of a particularly beautiful and specially coloured material; and though marble is greatly restricted in its gamut of colour, its texture when polished and its diaphonous quality are most grateful to the eye; for even when it is of one colour this colour is never uniform, but has infinite varieties, which prevent satiety, and remove it from the category of inartistic human manufacture; the finer flowered sorts have in their colouring every sort of motive and caprice that can astonish and charm us.

In marble there are no blues except in name, " blue imperial " and " blue Belge "; and if we want an azure we must employ fine stones, such as lapis lazuli or turquoise. Although there are many greens—verde antico, Genoa green, Pyrenean green, Irish green, Anglesea green, and Greek green, the brightest perhaps being the green porphyry of the Morea—none are brilliant, except the yellow green of Irish and the green avanturine of India. There is a silicious breccia with a green ground from Egypt; and some sorts of cipollino are of a dull green, in stripes, in curls, or in waves. There are pure whites, pure blacks, and there is a pure red, rosso antico; and many impure reds, such as porphyry, Irish red, Verona, rouge griotte, Languedoc, and a red Numidian breccia, not to speak of the poor reds of Devonshire and Belgium, and red alabaster. There are no pure browns, but there are those as tawny as a lion's skin, and generally marbles are more or less variegated. But when we see what the Saracens did with tiles, when they were restricted to a white ground, to two or three greens, two blues, and a purple, we need grumble at nothing but our own incapacity, if we cannot produce all sorts of happy effects with marble. Many of the marbles are charming from their strange contrasts and bold flowering, and some have divine harmonies, such as peach blossom; some look like a leafy forest, as verde antico, while the pavonazzetto and veined, often beautiful in themselves, are of infinite value as connecting-links between heavier masses of colour.

Marble has, too, this great merit, that, besides its own intrinsic beauty, it enables us, by inlaying it, to make imperishable coloured decorations. The hope of fame, and even the hope of our work lasting, encourages us to make prolonged efforts to insure success, while nothing is so disheartening as the probability of the early destruction or perishing of our work. Painted decoration soon gets grimy in London, and, under the happy leasehold system, the next tenant may cover the finest decoration with three oils and flat, which happened to a decoration by Godfrey Sykes. To do anything connected with architecture well not only wants genius but knowledge; it would take ages to learn by trial and failure what may be learnt in a few years by the study of existing successes in marble, formed by juxtaposition, by inlays, or by both.

As there is monumental form, so is there monumental colour, and it is as hard to get one as the other. When you see many specimens of coloured marbles together, the softness and broken quality of the colours make us think it would be impossible to make frightful discords with them; but such is the skill of man that he has been able to get vulgarity and repulsiveness out of marbles. Veneered marble pedestals and terminals for busts or statuettes frequently give us the horrors.

The safest course to take is to adhere to one colour, or to some strong contrast of two colours, such as black and white, dark purple and white, or dark green and white; and one of these courses has often been pursued when monumental effect has been aimed at. In marble

mosaic black and white has always a dignified effect, if a proper proportion between them is adhered to; but I do not know that it is more dignified than that superb pavement called opus Alexandrinum after Severus Alexander, a mosaic of red, green, and black porphyry inlaid in white marble, twisting like a serpent round great slabs and roundels of porphyry. This pavement is often imitated in limestone marbles, and looks very well when new; but the marbles quickly lose their polish and colours by being walked on, while walking over porphyry only polishes it. Black and white used for columns, balustrades, and walls has a very dignified effect: this may be seen in churches abroad, and in some of the large tombs at Westminster Abbey. But in this case, as in pavements, the white must greatly predominate, or else the effect is too funereal. The Italian Quattro Centisti produced great impressiveness by large slabs of purple porphyry in their white marble tombs, as may be seen in those at La Badia at Florence by Mino da Fiesole. Where monumental effect is wanted everything should be sacrificed to it.

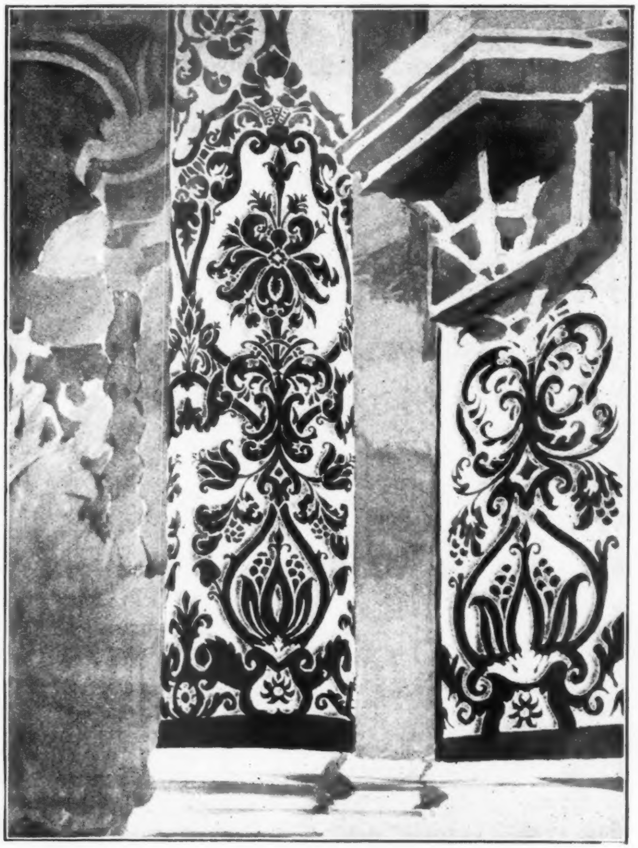


FIG. 1.—INLAID VERDE ANTICO, FROM THE JESUITS' CHURCH AT VENICE. Sketched by Cav. G. Boni.

We do not, however, always want to be safe, nor do we always want to produce an austere effect; we sometimes want to produce richness, magnificence, or gorgeousness; sometimes we want delicacy or loveliness. The same rules hold good in marble as in painting: if you want to have a white or light ground, with colour interspersed, you must either have the other colours very light, or bright colours in small pieces; while if you have a dark or low-toned ground, then white or very light tones are your jewels, and must be used sparingly.

A few maxims may be given about the use of flowered marbles. Their beauty is best shown in slabs or large masses, and the surface should not be broken up by mouldings, especially by small ones; and though such marbles have been carved in classic days, it was generally when taste had somewhat decayed. There are effective carved pieces of coloured marble, mostly verde antico, to be seen at Ravenna and at Constantinople. It is well to make contrasts vigorous; and it is not amiss to use plain marble to contrast with flowered. Dark marbles absorb so much light that slight variations of colour are scarcely perceived; for example,

Genoa green, Belgian blue, common grand antique, and Pyrenean green are scarcely to be distinguished from one another, unless they be in a very strong light. White capitals and bases, as a rule, look weak if used in conjunction with dark flowered shafts, I think even with pavonazzetto shafts. For study in the use of coloured marbles the interior of the Pantheon may be recommended for solemnity, St. Mark's and St. Sophia for dignified richness, and the interior of Siena and Pisa Cathedrals for striking quaintness, the Mausoleum of the Medici for funereal effect, and the interior of the Cathedral at Genoa for cheerful magnificence. A deep green shaft of insufficient length at the north-west end of this cathedral has been eked out with white marble, and is by no means objectionable. The pulpit of St. Mark's is well worthy of study, with its golden cupola, the pulpit of porphyry, the reading-desk of verde antico, supported on columns of rare marbles; and so is the little isolated chapel in the north aisle, with its dark shafts and roof of gleaming white.

In my young days the use of marble was confined to hall-paving, chimney-pieces, and tombs. The first instance I recollect of marble being largely used as decoration in my time was at Mr. H. Hope's house in Piccadilly, now the Junior Athenæum; the cage of the staircase was decorated with slabs of marble. Subsequently Mr. Holford had his staircase at Dorchester House, as well as its cage, of marble, and the door-cases of the first floor were made of splendid Chian marble, called by the Italians Africano, a breccia of black, white, crimson, and flesh colour or pale green, in large masses. The staircase cage of Lord Leconfield's mansion in London is lined with pavonazzetto, with a black marble skirting, and the balustrades are of Rose du Var capped with Genoa green, and with monolithic shafts of red Devonshire. At Goldsmiths' Hall the staircase and its cage are of marble, and some of the steps are the largest monoliths in London.

Nothing can give such an air of stateliness to the inside of a building as marble if properly used, while effects of loveliness, of richness, of dignity, of magnificence, and of sumptuousness can be obtained; and how can wealth be better bestowed than in presenting this stateliness, especially if it be enriched with the finest sculpture this age can produce! "A thing of beauty "is a joy for ever," and the finding of one sculptured sarcophagus at Pisa led the way to all the lovely sculpture of the Renaissance. But I most earnestly beg of you to avoid the use of marble if you have not that rare gift of being able to harmonise colours, and have not perfected that gift by study, observation, and trial; for nothing is easier than to give the wrong effect. I have seen dining-rooms lined with marble that had the appearance of mortuary chapels; and hard though it be to effect, I have seen staircases made more vulgar by the injudicious use of marble than they could have been made by the commonest paper, and which might have been wholly avoided by a coat or two of zinc white; so many people mistake costliness for artistic beauty. It is always difficult to gauge our own incapacity, but we ought to try when so costly a material as marble is to be used.

Of late years the taste for marble has enormously increased; it has been much affected for some of our public buildings, as well as for the staircases and grand dining-rooms of hotels and restaurants. Numidian marble has been largely used at the upper halls of the National Gallery, and in the hall of the New Gallery in Regent Street, and in the latter with an intermixture of green Carystian. Quite lately Mr. Collcutt has built a magnificent hall, wholly of red marble, at the Holborn Restaurant, where red Verona is accentuated by shafts of crimson Numidian breccia, and by pedestals of rouge griotte. We may hope to see a general revival of this and other magnificent tastes—as coloured mosaic on a gold ground is now much used for exterior decoration in London—and we may live to see Monsieur Garnier's vision of Paris realised here. He says: "The inflexible Commission of Public Ways will have its period of "reaction, and without hurting anyone, everyone may build his house without making it match

"his neighbour's; the ground of the cornices will shine with eternal colours, the piers will be "enriched with sparkling panels, and friezes of gold will run the length of our buildings; monu-"ments will be of marble and enamel, and mosaics will make all admire colour and movement. "This will not be false and paltry luxury; it will be opulence, it will be sincerity. Our eyes, "familiarised with all these marvels of colour and of brilliance, will force on us a modification "of our dress, which will be coloured in its turn, and the whole town will be an harmonious "reflection of silk and gold."

II. By William Young.

THE object of the Papers and discussion to-night is not to go into the question of marble itself; that has been done before, and we will all agree that it is one of the most beautiful, if not the most beautiful material which nature has provided for the architect's use. The idea we have in view is to consider how we can best use it in our work. My remarks will be confined to the use of marble in interiors—or we have some little preliminary difficulty in our climate, not to mention cost, in the use of marble to any extent externally; and they shall be only the remarks of a working architect gathered from his own experience and observation, and not those of the theorist critic or *dilettante*, who from his easy-chair criticises our works and tells us exactly what to do and what not to do, without knowing anything of the difficulties and conditions under which an architect works, and the sacrifices he has sometimes to make in order to do anything moderately good at all.

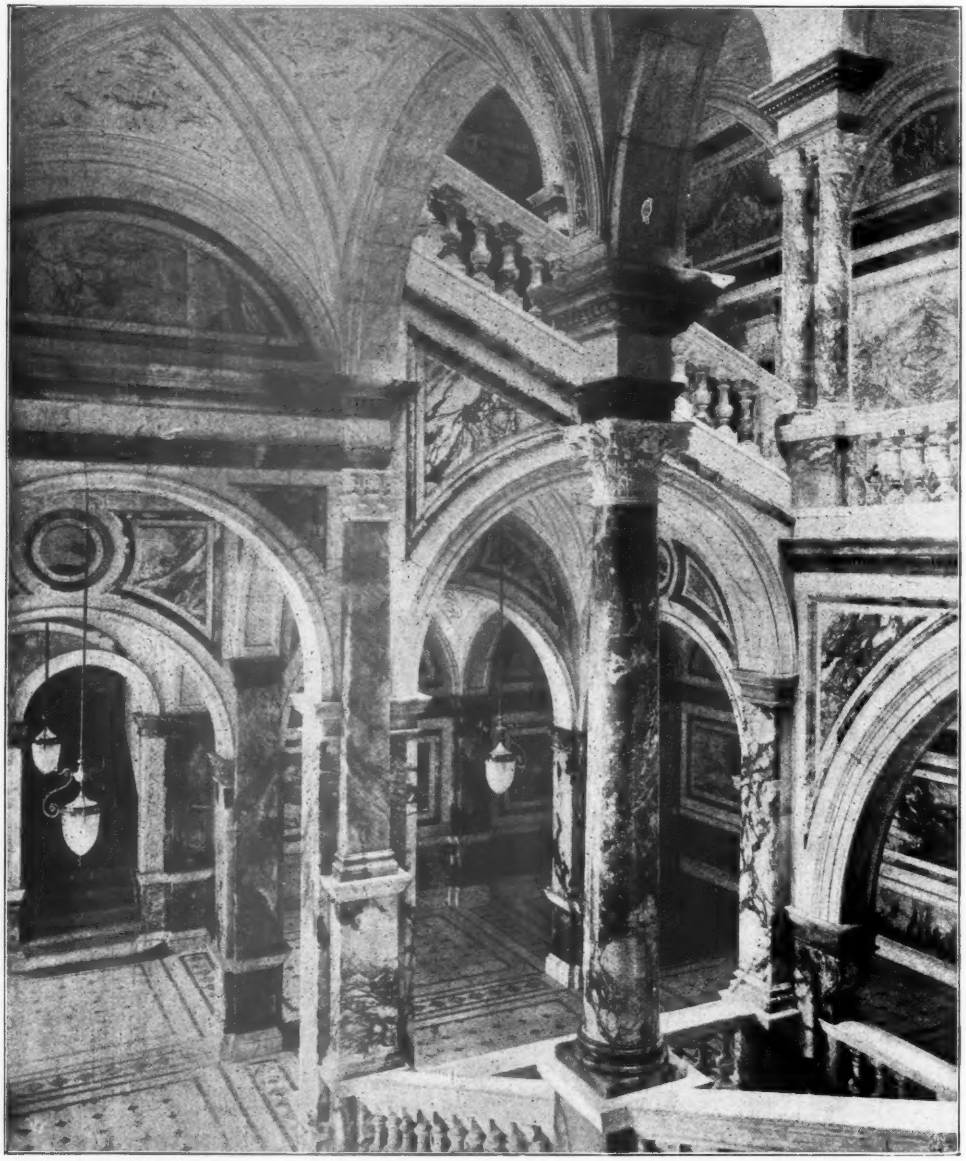
Marble has never been a popular material in English architecture. If we look down the course through which architecture in Great Britain has come down to us, for, say, 1,000 years—and that period nearly covers our architectural history as a nation—we shall find marble conspicuous by its absence in our buildings. If we go further east, and go back another 1,000 years further, to a time when the architecture of the ancient Briton was as scanty as his clothing; if we go to Italy and Greece and look at their architecture, at the beginning of the Christian era and before it, we shall find marble conspicuous by its presence.

During the great cathedral-building era in England marble was but little used, probably because at that time it was not procurable in sufficient quantity, as well as that it was not suitable for the richly clustered columns and elaborate and deep-cut mouldings of Gothic. But even at a later date, in our own beautiful St. Paul's, which is eminently adapted for marble—marble in construction as well as decoration—it is only in our own time that any serious attempt has been made in the use of marble. In domestic architecture of the past, if we look at Queen Anne and Georgian, which is so popular at present—I should like to italicise *at present*, for we have changed our architectural love a good deal during the last fifty years, and it remains to be seen whether we shall be more constant to our last new love than we were to those which went before—we remark that even in Queen Anne and Georgian we see only a very timid use made of marble, mostly in chimney-pieces—beautiful chimney-pieces certainly, rich both in colour and real sculpture—and perhaps a hall floor and columns at the end of a room, although we must admit that the columns are not always real marble.

If we want to see marble used in architecture we must go to Italy, the home of marble-work—go to Genoa, to Venice, to Rome, where we shall see marble used in architecture not only in decoration, but in construction, in halls and staircases, in churches and cathedrals.

It will, I think, be admitted that the employment of marble in building has developed very much within the last forty years in England, and is perhaps developing more at the present moment than it has done at any time during the present century, and there is every appearance of its being still more used in the future.

Much beautiful work in marble chimney-pieces and halls has been done in recent years; but the question is, Do we always use it in the best way and in the right place? If not, the



Photographed by Bedford Lemere

FIG. 2.—MARBLE STAIRCASE, MUNICIPAL BUILDINGS, GLASGOW

sooner we know of it the better; and it is to be hoped that the discussion of the subject to-night may assist us in this matter, for, if I interpret the feeling of present-day architects aright, it is that we have got past the days of prejudice and routine in our work, and are

anxious to make the best and truest use of marble, as of every other material. In accounts of some new building just completed one reads of its magnificent marble hall; we go and see it, and what do we find?—a great hall having the walls lined with marble from floor to ceiling, and a marble floor and stair. But how is it done? The walls are lined with slabs of marble, often each slab beautiful in itself, but set in courses marked off by horizontal and vertical joints, just after the manner of the marble wall-papers with which the walls of the passage and stairway of every ordinary house were covered some years ago. Surely the true use of marble means something more than this. Is it not the architect's work to use marble as he does other materials, to follow a certain order and scheme to bring out his design?

It is only repeating a truism to say that marble lends itself to simplicity of design and delights in broad surfaces. But, still, it requires design to become architecture. To cover a wall with slabs of marble laid at random as they come to hand, even supposing each individual slab quite beautiful in itself, cannot be called design, and only produces confusion, a too much repetition of beautiful objects without order, of which the eye wearies and the mind gets tired. It is the architect's province to so arrange, adapt, and apply all this beautiful material as to bring order out of confusion, and in so doing even bring out more fully the beauty of the material itself. Someone may say that, as the material is beautiful in itself, it wants no aid from the architect. It seems to me that, just because the material itself is rich, rare, and expensive, it is only an additional reason why we should bestow all the more thought and skill on the way it is used. To illustrate this let me draw a simile. Let us picture to ourselves a painted hall which is also beautiful. We admit at once that the beauty is due to the skill with which the paint is arranged, and not the material itself, although, taken to pieces, every separate colour in itself may be beautiful. So it should be in the use of marble. We should use it as a painter does his colour, and make the marble our servant, our vehicle to realise our idea.

Select a large and beautiful piece of marble with life in it, as they say; make this a centre, and work round it with quieter-coloured marbles and smaller pieces, to bring out more fully by contrast your beautiful piece, in place of wasting its beauty by crowding around it pieces all equal to it, so that the eye does not know on which piece to rest.

Let us not forget that it requires the handiwork of the workman to bring out the beauty of marble. It requires the labour of the hewer, the sawyer, and the polisher before the beauty of marble is revealed; but when we go thus far it is only a beautiful material. To make it beautiful in architecture we must go one step further, and add thought and skill. This is the same thing as a great painter recommended—mixing brains with your colours. We should mix brains with our marbles. A little bit of Mr. Alma Tadema's picture "At the Shrine of Venus" will explain my meaning. There you have a dado of a light tone with simple vein, above it the wall has a large and beautiful piece of marble as a centre or panel, around it first a narrow band of lighter tone, and outside a margin of darker tone, the whole upper part being stronger and richer than the lower part. Of course the arrangement could be reversed—dark below and light above. There is the opposite extreme to the marble-lined hall with slabs taken at random, without design and arrangement, and that is where there are too much design and too many colours. I have in my mind now a great marble hall, erected thirty or forty years ago, which from its size would have been magnificent, but owing to the use of too many colours, badly arranged and out of harmony, the effect is ruined and made vulgar.

In using marbles in a large way I would say the first thing is to let your marbles be few but well chosen; and the second, let your mouldings be simple and not too many of them.

Not only is there an infinite variety in marbles, but there is such a great variety in each particular marble. For there are *colour, tone, and expression* in marble. In some places you want marble with life in it, in other places you want it quiet, so that three or four different

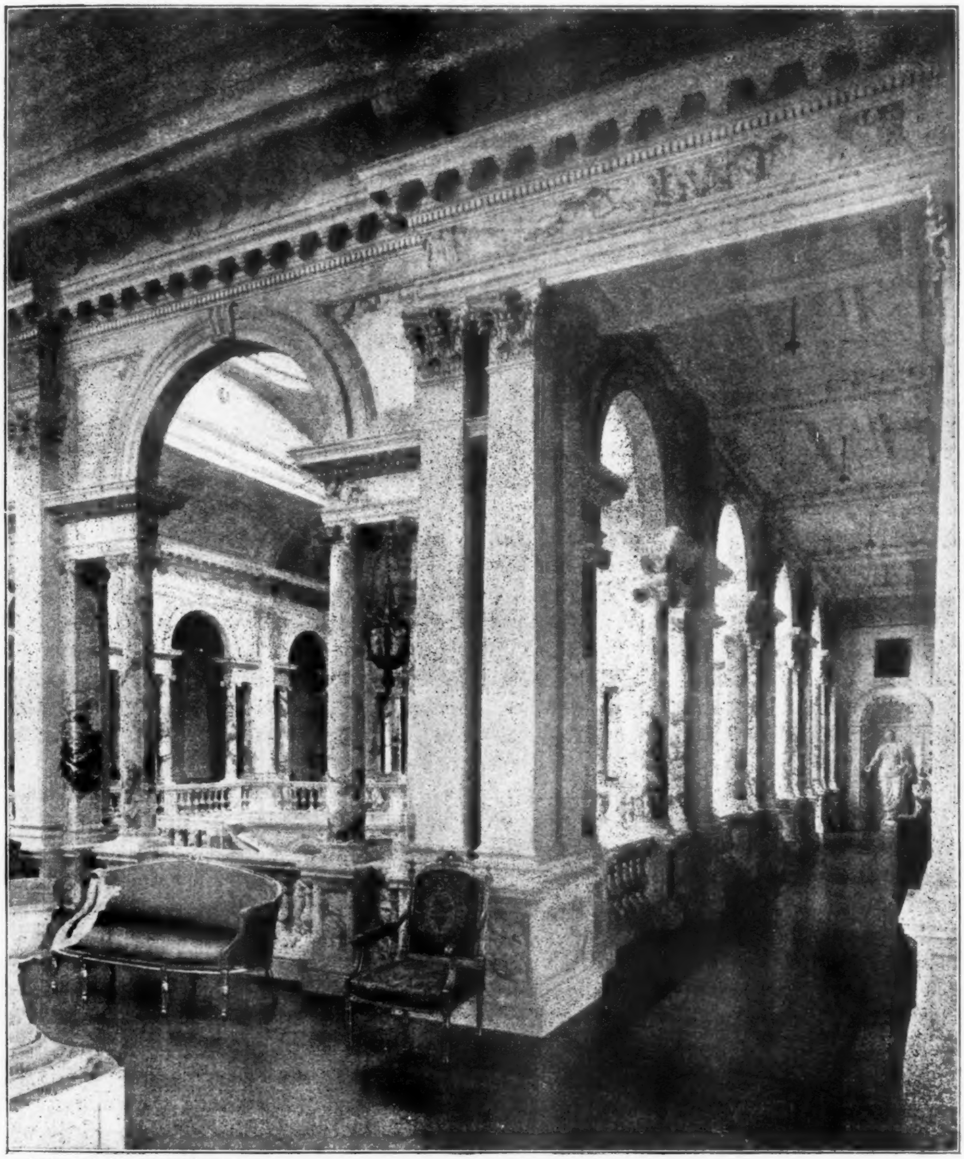
marbles will generally be found sufficient for any work, from brilliant to sombre. Fix your keynote for the leading tone, and let all the others blend with it and enhance it. Are there

Photographed by Bedford Lemere.

FIG. 3.—STAIRCASE HALL, GOSFORD HOUSE.

not only four strings to a violin, and is there anything in the whole range of musical art that cannot be accomplished with the four strings when touched by a master's hand? So in architecture, with three or four different marbles handled by a master, there is nothing within the

range of architectural art, from simplicity to magnificence, that the architect cannot accomplish with them. A material rich in itself does not require too much trimming. A garment of



Photographed by Bedford Lemere.

FIG. 4.—STAIRCASE HALL, GOSFORD HOUSE.

rich material and rich colour is only made vulgar by the use of too many different colours in the trimming. This brings us to the good old rule which we find exemplified in all the great architecture of the past. In all our magnificence let us study simplicity; in all our

richness let us study repose: sound, wholesome rules for life; and sound, wholesome rules for architecture.

Hitherto I have referred principally to wall-surfaces. But the same reason for selection applies to columns, arches, &c.; using any block of marble that comes to hand will not produce the effect we desire. We may have to cut up many blocks of marble before we get the special piece required for a particular place. Take a column, for instance. Suppose you specify a breccia column; and it is just the same with most other marbles, you may be supplied with a column which is breccia, but not at all what you want—in fact, quite out of tone with the place for which you want it, and out of harmony with the surrounding work. Sometimes much difficulty will arise in finding the particular type of marble you want. I remember as an instance that for the front column in fig. 2 the contractor had not got any marble that would suit the purpose, and we had to search through all the marble stores in the country before we found what we wanted. The same thing occurred with the alabaster columns in the upper tier. We could get dark alabaster like the pilaster behind, but even the quarry could not at the time produce the lighter coloured columns that we wanted. I need not say that all this took much time and trouble; but you may always put it down that good marble work cannot be done in a hurry.

If we use marble columns let them be constructive, and not useless columns planted on for decoration; and, if possible, let them be monoliths. There is nothing absolutely wrong in jointing a column; but there is a dignity, an impression of work well done, in having columns in one piece, which the jointed column never has. Square pillars should also be solid marble, and not brick cased with one-inch slabs of marble, jointed so as to imitate solid masonry. This is a deceit soon detected, and gives the impression that the work is all cheap veneer done for much show, at the smallest possible cost, but at the expense of sacrificing truth. Better genuine solid stone than this. Where it is necessary to carry through the colour of the marble, panels can be inlaid so as not to imitate solid masonry. There is no sham in this. The same applies to walls, which have been referred to; for to build walls with solid blocks of marble would be useless waste; but let the marble be treated so as to show that it is a lining, as in the picture, "At the Shrine of Venus," I have referred to, and not to imitate solid masonry.

While on this subject of marble linings I am almost forced to refer to a use, or rather a misuse, of marble which has become so common with us that we look upon it as a matter of course, and do not see the sham of it. I am reluctant to mention the box marble chimney-piece, made by the thousand, and seen everywhere. This is not a true use of marble, and it is not architecture; but so general is this use of marble that it seems to me that it has created the impression, both with the architect and with the mason, that marble blocks should be cut up into 1-inch or ½-inch slabs, just like a log of wood, and used in the same way, with this difference: the wood is made to look like framing and panelling, which it is, but the slabs of marble are used, one in front and one on each side, to try and look like a solid block, which it is not. This practice has become so common that the true idea that marble should be used solid, like stone, seems for the time being to have been overlooked.

In sculpture white marble should, of course, be used; but for ornamental carving pure statuary is not essential. In fact, statuary marble is too pronounced a white to go with coloured marbles.

In the carved capitals shown in fig. 2 we used blocks of white alabaster, which is not a pure white, but a very light tone, almost white, with here and there a little cloud of deeper tone. This, in my opinion, was more in tune with the coloured marbles than pure statuary would have been. Istrian stone is also a good material to use for carved work, and indeed

also for sculpture in conjunction with marble. I used it for a richly-carved chimney-piece in a marble hall, and it harmonised well with the marble work.

In mouldings it is not necessary to have a uniform colour: sometimes it is much better that the colour should be broken. This, however, brings us to a larger question, and one in which there will probably be much difference of opinion—viz. Should Colour follow Form? On this question Mr. Ruskin, in the "Lamp of Beauty," arrived at the conclusion that in nature colour never follows form, neither in animal, bird, nor flower, but goes a free way of its own, independent of form, or what we may call construction, and he sums up his careful study of the matter thus:—"I hold this, then, for the first great principle of architectural colour, "Let it be visibly independent of form." Some of you will differ from this view; but in my opinion, based on some years' experience in the use of marble in a large way, I consider there is much sound truth in it as a principle and theory for our guidance—although when we come to actual work in architecture we find that colour must, as a rule, follow form. But there are exceptions to this rule, as to every other. For instance, in the large picture panel I mentioned before, one wants, indeed must have, a different colour following the lines of form to emphasise it, just as we do in the frame of a picture; although some painters, I am aware, do not always do this, but run the colour of the picture through the frame.

In architecture, however, this must be done with great caution, and not too often. In the spandril panel in fig. 2, for instance, you will see that it is necessary for the architecture that the colour should follow the form; again, in the cornice dividing the lighter wall below from the dark frieze above, colour must follow form, or the effect of the frieze would be destroyed. But in the same example there is an instance where the cornice is also dark marble over a lighter coloured arch, where a splash of light tone runs through the cornice, in an erratic way if you like, and connects the light tone of the marble below the cornice with the light ground of the lunette panel above it. In this instance the colour does not follow the form, and, in my opinion, it has a much better effect than if the cornice had been of one tone throughout.

In some of the spandril panels illustrated, the colour does not entirely follow the moulding, or the form of the panel, but runs through them all in a broken way; and it gives, in my opinion, a feeling of softness by not emphasising the form, but at the same time not entirely obliterating it.

Bases and caps, as a rule, may be of different colours from the shaft of a column; and, as a rule, it is better that the base should be a strong colour if the shaft is a strong colour. In one of the columns in fig. 2 where the colour is strong the base is dark and veined; and, in my opinion, it gives a much better rest and support to the shaft, by spreading the colour at the bottom, than a white base would. In the columns placed over those to which I have referred, white bases were used; but the shafts are also light in tone, and on the whole I do not consider the white base gave so good a result as one as dark as or darker than the shaft.

So it comes to this: if you make colour follow form strictly and severely, the result will be that your work will be hard and mechanical; if, on the other hand, you let the colour break up the form too much, the result will be that your work will be restless—and we know that anything that destroys repose is fatal to good work. By this reasoning we arrive at the conclusion, which is exemplified in all the great architecture of the past, that in this matter, as in everything else, there is a true, intelligent medium to be observed: a medium which is the outcome of careful study—a medium, as I said before, which tempers magnificence with simplicity, and richness with repose.

Hitherto I have considered only *how* to use marble; but there is a question which should take precedence of this, and that is *where* to use marble. If the *where* is wrong the *how* can

never be right. We may or may not have used it where we ought not to have used it—but one thing is certain: we have not used it where we ought to have used it. We have marble in our clubs and restaurants, our shop fronts and fish-shops; but in our churches marble is conspicuous by its absence. It is difficult for us to take a true view of this matter, because we cannot help looking at things through the medium of a large amount of inherited influence and prejudice, and as much surrounding influence and fashion.

At the present day there is an unhealthy idea abroad among architects that we are the sole arbiters of what is good and bad in architecture. We are too much in the meshes of fashion and change, and seeking after some new thing. What we thought was right and admired thirty years ago is now passed by with contempt; and what we bow down to, and copy, and worship now, we shall pass by with a shrug of the shoulders twenty years hence. All this is not a true understanding and appreciation of architecture. It is only a temporary fad, a malady due to living too fast, and over-eagerness to be original and fashionable; but it will pass away in due course. We ought to know from our knowledge of architecture in the ages which have passed that what is really good in one age is good in all ages. At present with us there is too much disregard of the architects of the past, and a total indifference as to what may be the opinion of those of the future regarding our work. Let us try for a moment to throw off this modern influence which envelops us like a net, and endeavour to see ourselves, or rather our work, as others will see it and criticise it with regard to this question of the use of marble. For the future will sit in judgment on our work, and reverse a great many of the verdicts we arrive at now amongst ourselves as to what is good work in architecture and what is not, and the architects of the future will be in a much better position to give a true opinion on this matter than we are. Will you permit me to try and get a forecast of such an opinion?

Let me for a minute take myself away to a point of view 500 years hence, and throw back a spirit-light view on the screen of your minds. You may call it looking backward. Say it is the year 2395. I am present at a meeting of an Institute of Architects, and one of the members is reading a Paper. The subject is, "The Use, Non-use, and Abuse of Marble in "the Architecture of England at the End of the Nineteenth Century," and I note these words as they fall from the speaker's lips: "In the palaces of the nobles and in the homes of the "princes of trade and commerce marble was used to a large extent. Their club-houses and "municipal buildings were enriched with marble work, but it is supposed that in all buildings "erected by the Government the use of marble was prohibited by law, as we can see no traces "of it. Their restaurants and halls, where the people assembled to eat and drink and amuse "themselves, were made sumptuous with marble and gilding. And even their drinking "saloons, which they called 'Gin Palaces,' were made over-gorgeous by the *abuse* of marble, "gilding, and ornamentation. But if we turn to their churches, where we should most expect "to see beautiful marble work, we find it conspicuous by its absence, and in its stead there is "dingy brick and plaster, and sometimes one of their cheaper kinds of stone, *sparingly used*. "When we consider that at the end of the nineteenth century England was richer by far than "she was in the earlier twelfth to sixteenth centuries, when she raised noble cathedrals in every "part of the land; and when we consider, further, that many of the people had come to know, "as we know now to a certainty, that all this great advance in civilisation, in knowledge, in "power, and in riches beyond the dreams of Roman emperors, to which England had attained, "was due entirely to one cause, viz. *The Christian Religion*—when we consider this, it will "strike us as a strange anomaly that, while they made their palaces of pleasure and halls for "eating and drinking magnificent with marble work, they could have been content with dingy "brick and plaster for their churches. While they used for their places of amusement

"and indulgence the richest and most expensive material which God had made; they at the "same time used the cheapest and commonest material for what they themselves called the "House of God." Now let me put away the lantern and its light, and without trespassing further on your time and patience leave this picture to speak for itself.

III. By William Brindley, F.G.S.

PROFESSOR AITCHISON has just told us that polished white marble has this great charm: you seem to see into its substance. Now this seeing into the material is one of the most expressive remarks that can possibly be made, and defines precisely the white marbles used by the classic Greeks and early Romans, and later by the Byzantines; but this definition rarely applies to the white marbles, now commonly used, coming from Carrara. The bulk of this material is of a bluish tone, of amorphous crystallisation, and more or less opaque. White marbles, as a rule, ought not to have a glass polish. Down to the fifteenth century in Italy they usually worked the surface with the chisel, sand-rubbing it up at the most. When boldly crystalline white of warm tone is carved (as in "egg and tongue"), and decorated with ochres, heightened with deep-coloured dead gold, an effect is obtained which can never be got by the painter-decorator. It is refined and classical. The polishing of coloured marbles is requisite, but some of these, like the ancient Synnadic, must not receive more than an egg-shell polish.

No doubt the Romans were right in making their coloured marble columns monoliths; the grandeur of effect produced is worth the cost and trouble. Where the block varies in colour from end to end, the deeper colour had better be selected for the bottom. When they have to be jointed, a shaft of three stones is better than two, if plain columns; but if reeded and fluted, then make the joint at the top of the reeds one-third up, as in the giallo antico columns of the Arch of Constantine. If jointed, the markings ought to go the same way of the bed, not—as in The Oratory, South Kensington—any way the stone will make. When pilasters have to be cased with marble to carry out the colour scheme, they rarely look consistent if treated with an entasis; it is best to keep to the orthodox rule, and make them straight—in addition to which the entasis is a costly business.

For surface decoration of walls and floors, there is much difference of opinion as to the opening out of slabs to produce a pattern, either continuous or in panels. My opinion is that it is thoroughly legitimate, for it in no way represents a sham. It is the method used in St. Sophia and at St. Mark's, also in San Vitale, Ravenna, which are the best examples we have. If horizontal courses, then, as in Northern and Central Italy, in broad and narrow courses, the latter, dark. Architects, when designing, often start with the painter's contrast scheme of colour; but this rarely succeeds for marble, owing to the changing freaks of nature in the same block. The safest way is to work for "values," and decide the colours afterwards by putting the actual materials in juxtaposition. Use as few colours as possible. Frequently, pleasing results are obtained by the lighter and darker parts of the same marble, such as the plain cream statuary white out of the modern pavonazzetto used as bands to panels of the richer marked portions. Mr. Ernest George has produced good work treated boldly on this principle. Light and dark alabaster go very well, and may be supplemented with a light greyish green cipollino. This latter treatment may be seen at the Jews' Synagogue, Bayswater. Light giallo antico with statuary, or pale sienna and statuary, produce delicate work.

Walls of circular plan always look well when treated with long, narrow, upright slabs with "ribbony" markings, making a series of polygonal faces; this is both the Byzantine and Arabic

method. Old cipollino is a suitable marble for this work, or for a continuous deep dado, as in the gallery of St. Sophia; it produces a chevron pattern, much like some of the old tapestries one sees about Nuremberg. Mr. Alma Tadema has treated his studio with upright long panels of cipollino, not quite vertical; the effect is good and the method new. Walls to receive marble slabs should be dry, and the work is best fixed hollow.

Black and white and Verona red and white are always safe for pavements, but it must be borne in mind that the dark parts become paler and softer in effect with wear and age. When making notes of old marble work in Italy I specially note those combinations which are not quite satisfactory, and make memoranda.

Marble mouldings want special study. They require all the undulating delicacy of the Greek. Almost a different section might be made for each coloured marble. Much remains to be done in this way. There are a few younger men certainly on the "right track." Differences of opinion again occur—as in the boxing-up of chimney-pieces—but the beautiful examples of the "Adam" style surely show that the method is right, even if it is abused by bad Belgian work sold by ironmongers throughout the country. The Adam chimney-pieces are always cut out of the choicest materials; they are, as a rule, of delicate workmanship, and their method of construction, I think, is worth study. The original drawings of many are at Sir John Soane's Museum. Chimney-pieces with bold mouldings in coloured marbles, with sections of flat, round, and hollow, such as Mr. Norman Shaw delights in, are always grand. One of the most difficult marbles to use is the Mexican onyx. A large ecclesiastical edifice is now being lined with it. The effect is as bad as the material is choice. The French seem to be the only people that are successful with onyx, when they use it with gold and ormolu. It certainly suits Paris better than London; it may be that the climate helps it.

For exterior work, plaques of porphyry, red and green, might be used, as in the Palazzo Doria, Venice. Some of the serpentinian greens, like the Connemara, stand very well. The purple-coloured Levant brèche is used very freely in Paris, and retains its colour well.

Mr. L. ALMA TADEMA [*H.A.*], R.A., thought it a great privilege to be allowed to propose a vote of thanks to the readers of the admirable Papers to which they had been treated. They had learnt a great deal from them, and he should like to add two or three things within his own experience. In his studies in Italy he had found that the oldest houses were decorated with slabs of imitated marble painted on the wall. In many houses he had found that the pivots of doors contained large pieces of beautiful onyx and precious marbles, inlaid with gold, and he had come to the conclusion that the use of precious marbles in Italy was much older than they thought. Where could they have got those beautiful marbles from? Besides that, Mazois, in describing the ideal Palace of Scaurus, speaks of the atrium having columns of Etrurian marble many metres high. That the Romans had a great love for their columns was proved by the fact that when Julius Cæsar was in want of money he taxed the marble columns, and filled his coffers. In reference to certain remarks in Mr. Young's Paper, he should like to say that he himself was always afraid of breaking up the marble. A flat surface might be broken up as much as they liked, but it was a pity to break up a marble with a beautiful, refined moulding. As for the view that their successors might have 500 years hence, it was interesting to think that perhaps in judging of the use of marble in the present day they would take into account the political state of England at this time, when the workmen were told that there was no greater happiness than to have a good dinner; while no workman was ever told, by the so-called friends of the workmen, that there was happiness in working and producing something. So, naturally, what they liked most and cared for most were the places where they went to amuse themselves; and, of course, the churches were not considered at all. They had been shown by Mr. Young some delightful views of a building decorated with marble. He was afraid he could not admire very much those marble pictures; he should prefer pictures with subjects. It was always interesting to see, as they could see in so many ancient buildings, the history of the place depicted. It was a bit of artistic decoration which must not be forgotten.

Mr. GEORGE SIMONDS seconded the vote, and said that, as a sculptor who had used marble

for a great many years, the Papers had been a great treat to him. He thought that the authors had been rather unnecessarily down on the use of marble for exterior purposes. It was all very well to say that the climate was bad, and that marble would not stand out-of-doors; but there were certain kinds of marble that stood out-of-doors uncommonly well. For instance, there was the Ravacione marble, which was common at Carrara, which would stand out-of-doors, and bear the winters as well as Portland stone. He knew of a case in point. A few years ago he had to make a fountain in which part of the work was of bronze; the figures were bronze, and some rock was of Portland stone and some basins were of Ravacione marble. That fountain had stood for three or four years through extremely bad winters, and the Portland stone, which, of course, was always wet, had cracked to some extent with the frost; but the Ravacione marble, which contained water which had been frozen solid through three winters, was just as good and fresh as when first put up. So he thought it was unfair to say that the climate of England was so bad that no marble could stand out-of-doors. It was true that the precious marbles lost a certain amount of their polish; but what material was there that would stand without any care, and why was it that they in England thought it essential that all the materials with which they made works of art should be left to themselves for ever and a day without the friendly touch of a cleaning hand? Their statues were left to get dirty, and then a man was told off to paint them bronze. Marble columns were put up, and the dirt and soot and rain allowed to get into them, and when they were thoroughly bad, and past praying for, they were scraped down and sanded off, and a fresh polish put on, and they were told that it was necessary to do this every year or two. It was not, if they would just give them a rub and a clean now and again.

*** See, in reference to the subjects treated in the foregoing papers, TRANSACTIONS, Vol. III. N.S. (1887), pp. 45–56, "Marble: its Uses as suggested "by the Past," with a list of the principal quarries worked in the time of the Romans, by Mr. Brindley; also some Addenda by Dr. Edwin Freshfield [*H.A.*]—the whole accompanied by illustrations of marble pavements and wall decoration. See, further, TRANSACTIONS, Vol. IV. N.S. (1888), pp. 5–14, "The Ancient Quarries of "Egypt; with an Account of a Recent Journey "across the Eastern Desert," by Mr. Brindley, with illustrations of porphyry pavements and pulpits and wall mosaics in Coptic churches. References to marbles and marble ornament found in North Africa are given in TRANSACTIONS, Vols. I. and II. N.S., in Mr. Alexander Graham's Papers on the Roman Occupation of Algeria and Tunisia respectively, with copious illustrations.

9, CONDUIT STREET, LONDON, W., *25th April* 1895.

CHRONICLE.

THE MARCH EXAMINATIONS.*

Final Examination: for Candidature as Associate.

The President announced to the General Meeting of last Monday that 95 persons were admitted to the Final Examination, qualifying for candidature as Associate, held from the 29th ult. to the 5th inst., and that 86 of these attended and were examined. This number included 75 who had been relegated from previous examinations, five Students, and six practising architects and chief assistants. The Examination was conducted simultaneously in London and Manchester, with the following results:—

	London.	Manchester.	Total.
Passed	24	2	26
Relegated in part	53	3	56
Relegated in all	3	0	3
Not passed	1	—	1
	81	5	86

The names and addresses of the twenty-six who have passed, and are qualified for candidature as Associate, here follow:—

ALLBERRY: Harry; 145, Brixton Road, S.W. [*Probationer* 1892].
BESANT: Robert Saxton; 26, Bedford Row, W.C.
COLLINS: Edward George; 47, Henslowe Road, East Dulwich, S.E.
COWAN: George; 21, Sussex Road, Southsea.
DELVES: Stanley William Worth; 23, Mount Sion, Tunbridge Wells [*Probationer* 1890; *Student* 1893].
DUNN: Alfred John; 22, Bristol Road, Edgbaston, Birmingham [*Pugin Student* 1895].
GREENOP: Edward; Bonham House, Bonham Road, Brixton Hill, S.W.
HAIR: Charles James; 7, Copthall, Twickenham.
HENDERSON: James Guthrie; 99, Fordwych Road, West Hampstead, N.W.
HUTT: Harry; Ivy Lodge, Brunswick Hill, Reading.
LEEDS: Percy; 7, Gilmore Road, Lewisham, S.E.
LOFTHOUSE: James Alfred Ernest; 62, Albert Road, Middlesbrough.
MAYOR: Charles Kay; 4, Mauldeth Road West, Fallowfield, Manchester.
MESSENGER: Robert; 28, Mayflower Rd., Clapham, S.W.
MIDDLETON: Orlando; 6, York Terrace, Cheltenham [*Probationer* 1890; *Student* 1891].

* The results of the Intermediate Examination held in March are given at pp. 375, 376.

MORRIS: Francis Edward; 156, Friar Street, Reading.
PECK: Frank; 19, Queen Anne's Gate, Westminster, S.W.
PENFOLD: Edward; High Street, Reigate.
PETTER: Frederick William; Bridge Chambers, Barnstaple.
REAVELL: George John Thrift; 42, Narbonne Avenue, Clapham Common, S.W.
SHARP: Cecil Alexander; Fir Tree Road, Banstead, Surrey.
SHAW: James Hewitson; 58, Granville Road, Walthamstow.
SHINER: Christopher Mitchell; 2, Walbrook, E.C.
STORY: Herbert; 1, Hamilton Square, Birkenhead.
WATKINS: Harry Garnham; Leyland House, Lincoln [*Probationer* 1891; *Student* 1893].
WAYMOUTH: William Charles; The Ferns, Highgate, N. [*Probationer* 1889; *Student* 1891; *Arthur Cates A.A. Scholar* 1892].

Preliminary Examination: for Registration as Probationer.

The President further announced to the General Meeting of Monday that at the Preliminary Examination held in London, Bristol, and Manchester on the 19th and 20th ult., 55 applicants had been exempted from attending; and out of the 83 examined, 59 passed, 22 were relegated to their studies, and 2 failed to pass. The total number examined in London was 47, of whom 32 passed; in Bristol 8, all of whom passed; and in Manchester 28, of whom 19 passed. The names and addresses, with other particulars, of the 114 newly registered Probationers, given in alphabetical order, here follow:—

ALLEN: Francis Henry; 28, High Street, Kettering [*Masters*: Messrs. John Ingman & Shaw].
ANDERSON: George; 41, Desswood Place, Aberdeen [*Masters*: Messrs. W. & J. Smith & Kelly].
APPLEYARD: Henry Milnthorpe; 41, Canning Street, Liverpool [*Master*: Mr. Edmund Kirby*].
AYLES: Herbert Weston; "Ventura," Trinity Road, Weymouth, Dorset [*Master*: Mr. A. J. Bennett].
BAILLIE: William; 160, Hope Street, Glasgow [*Master*: Mr. G. T. Ewing].
BALL: William John; 17, Wellfield Street, Warrington [*Master*: Mr. J. Thompson].
BEESLEY: Percy Montagu; 18, Bold Street, Warrington [*Master*: Mr. T. Beesley].
BELL: Arthur Edward; Normanby House, South Park, Lincoln [*Master*: Mr. W. Watkins*].
BIGGS: Alfred Ernest; 57, Compton Road, Highbury, N. [*Master*: Mr. R. M. Drake].
BIRD: Lennox Godfrey; 35, Castletown Road, West Kensington [*Master*: Mr. G. H. Fellowes Prynne*].
BLUNT: John Silvester; 2, Ivy Villas, Lincoln Road, Peterborough [*Master*: Mr. H. M. Townsend*].
BRIDGWATER: John Percival; Shawe Hill House, Alum Rock Road, Saltley, Birmingham [*Masters*: Messrs. Ingall & Son].
BROWN: Guy Alexander; 21, Falkner Square, Liverpool [*Master*: Mr. James Rhind].
BROWN: Herbert Elisha; 92, Woodchurch Road, Oxton, Birkenhead [*Master*: Mr. H. Story].
BROWN: John; 37, Albion Hill, Leicester [*Masters*: Messrs. Keites & Fosbrooke].
BUTTERWORTH: Robert Hepburn, B.A.Cantab.; 38, Upper Bedford Place, W.C. [*Master*: Mr. John Slater*].
BUTTERWORTH: Walter Cecil; 38, Upper Bedford Place, W.C. [*Master*: Mr. John Slater*].
CARTER: James; The Fernery, Low Birthwaite, Windermere [*Master*: Mr. Robert Walker*].
CHAPMAN: John Boswell; Cooper's Hill College, Englefield Green, Surrey.
CHORLTON: John Henwood; Pitsmoor Vicarage, Sheffield [*Master*: Mr. J. D. Webster*].
CLAYTON: Harold Robert; St. Cuthbert's, Whitstable Road, Canterbury [*Master*: Mr. W. J. Jennings].
COLLINGS: Tilleard Horace Osman; Trafalgar House, Petersfield, Hants [*Master*: Mr. H. T. Keates].
COMYN: Charles Heaton Fitzwilliam; Manor House, Manor Rd., Folkestone [*Master*: Mr. Bedford Joy, M.A.].
COOKE: Henry Fothergill; Hambrook, Bristol [*Master*: Mr. F. Bligh Bond*].
COOKE: Isaac, jun.; 19, Hertford Drive, Liscard, Cheshire [*Master*: Mr. T. Harnett Harrisson*].
COPLAND: George Donaldson; 20, Sandyford Place, Glasgow [*Masters*: Messrs. Clarke & Bell].
CORK: Harry Haighton; 29, Regent Street, Bacup [*Master*: Mr. Henry Ross*].
COTMAN: Grahame; 10, Boscobel Place, Alpha Road, N.W. [Architectural School, Polytechnic].
DALLAS: James; 3, Bright Buildings, Asylum Road, Birmingham [*Master*: Mr. J. G. Dunn*].
DANBY: Harold Henry; 10, Trinity Road, Scarborough [Denstone College, Staffs].
DARBYSHIRE: Percy William; Manor Park, Knutsford, Cheshire [*Masters*: Messrs. Darbyshire* & Smith*].
DAVIS: Charlie; 12, Castle Street, Swansea [*Masters*: Messrs. Bucknall & Jennings*].
DICKINSON: Edgar Gustav; 9, Belgrave Road, Birkdale, Southport [*Masters*: Messrs. Grayson* & Ould].
DRIFFIELD: William; Beech Mount, Harlow Road, Harrogate [*Master*: Mr. W. G. Penty*].
DUNAND: Claud Germain; 19, Birchington Road, Kilburn, N.W. [*Master*: Mr. Philip E. Pilditch].
EDWARDS: George; Osnaburgh House, 4, Osnaburgh Street, Regent's Park, N.W. [*Master*: Mr. G. W. H. Gordon*].
ELLISON: Walter Watkin; Eastbrooke, Midland Road, Wellingborough [*Master*: Mr. H. A. Cooper].
EMERSON: William Ernest; 8, The Sanctuary, Westminster [*Master*: Mr. William Emerson*].
FARMER: Frank Quentery; Millbrook Vicarage, Stalybridge [*Masters*: Messrs. Potts*, Son*, & Pickup].
FORREST: Frederick Victor; 100, Elgin Crescent, Bayswater, W. [*Masters*: Messrs. Perry* & Reed*].
FOWLER: Frederic Douglas; Plymleigh, near Plymouth [*Master*: Mr. H. J. Snell].
FROST: James Ernest; Saltlands, Bridgwater, Somerset [*Master*: Mr. A. Basil Cottam*].
GILFORD: Hubert Ernest; Edwalton Lodge, Edwalton, near Nottingham [*Masters*: Messrs. Brewill* & Baily].
GREGSON: Thomas Sedgwick; Scarborough [*Masters*: Messrs. Malcolm Stark & Rowntree].
HALE: Charlie; Fairfield, Queensberry Road, Kettering [*Masters*: Messrs. Talbot Brown* & Fisher].
HALL: Charles Llewellyn; The Glyn, Whalley, near Blackburn [*Masters*: Messrs. Stones* & Gradwell].
HALLEY: James Mitchell; 325, Byres Road, Hillhead, Glasgow [*Masters*: Messrs. J. Thomson* & Sandilands].
HAYES: James William; 9, Grosvenor Gardens, St. Leonards-on-Sea [*Master*: Mr. Henry Ward*].
HAYWOOD: Percival Joseph; 3, Norfolk Road Villas, Norfolk Road, Bayswater, W. [*Master*: Mr. C. R. Guy Hall*].
HEATH: Charles Simkins; 45, Lower Paddock Road, Bushey, Herts [*Masters*: Messrs. Pridmore & Anderson*].
HEATH: John Stanley; Kingsbridge House, Westcombe Park, Blackheath [*Masters*: Messrs. T. Roger Smith* & Son*].
HIGGINBOTHAM: Frederick William; Glenmaurice, St. Lawrence Road, Clontarf, Co. Dublin [*Master*: Mr. R. J. Stirling].

HIGSON: John; 87, Preston New Road, Blackburn [*Master*: Mr. H. S. Fairhurst*].
HIORNS: Frederick Robert; Viewfield House, Pasley Street, Devonport [*Masters*: Messrs. Hine* & Odgers].
HODGSON: Victor Tylston; Harpenden, Herts [*Masters*: Messrs. Waterhouse* & Son*].
HOPE: Arthur John; 4, Lane Ends, Atherton [*Masters*: Messrs. Bradshaw* & Gass*].
ISAACS: Charles Henry; 77, Netherwood Road, Sinclair Gardens, West Kensington, W. [*Master*: Mr. C. H. Flack*].
JAMESON: Norman Harold; 106, Gilnow Park, Bolton [*Master*: Mr. Thos. E. Smith].
JARDINE: Henry; 63, King's Road, Queen's Road, Peckham, S.E.
JEFFES: Reginald Herbert; 123, Glyn Road, Lower Clapton, N.E. [*Master*: Mr. P. E. Murphy].
JEFFRIES: Rupert; 74, Corporation Street, West Walsall [*Masters*: Messrs. Bailey* & McConnal*].
JENKINS: William; Abbotshill, Llandilo, South Wales [*Master*: Mr. David Jenkins*].
JONES: David; Penlan, Pentrevoelas, Bettws-y-Coed [*Master*: Mr. William Owen*].
JONES: Edward Oliver; Penrhyn Isa, Llandudno [*Master*: Mr. R. G. Thomas].
JONES: John Ivor Price; Ashdene, Cathedral Road, Cardiff [*Masters*: Messrs. J. P. Jones, Richards & Budgen*].
KIMBER: Frederick Henry; Carnarvon Street, Newbury, Berks [*Master*: Mr. W. H. Bell].
LACEY: Albert Edward; "Burleigh," Carlton Road, Bournemouth [*Masters*: Messrs. Pinder* & Fogerty*].
LAWSON: Herbert Sleeman; 7, All Saints Road, Clifton, Bristol [*Master*: Mr. W. S. Paul*].
LEED: James Constable; c/o Mr. R. M. Roe, 62, Basinghall Street, E.C. [*Master*: Mr. R. M. Roe*].
LEWIS: Arthur William; Ditton Lodge, Widnes, Lancashire [*Masters*: Messrs. Pierpoint & Fraser].
LEWIS: Charles Martell; 14, Charlotte St., Newport, Mon.
MACALISTER: Robert Alexander Stewart, B.A.Cantab.; 41, Torrington Square, W.C. [*Master*: Mr. A. S. Flower,* F.S.A.]
MacGIBBON: Alfred Lightly; 65, Frederick Street, Edinburgh [*Masters*: Messrs. MacGibbon & Ross].
MARSHALL: Ernest William; 17, Lansdowne Road, W. [*Masters*: Messrs. Waterhouse* & Son*].
MELLON: William Arthur; 73, George Street, Edinburgh [*Master*: Mr. H. J. Blanc].
MILNER: Stanley Joseph; 7, St. Andrew's Crescent, Cardiff [*Masters*: Messrs. J. P. Jones, Richards, & Budgen*].
MILLWARD: James; 12, Albemarle Street, Clerkenwell, E.C. [*Master*: Mr. T. M. Ellis*].
MORPHEW: Reginald; Rhuolas, Woodfield Avenue, Streatham [*Master*: Mr. A. J. Gale*].
MORTON: William Singleton; 3, Institute Road, Hendon, N.W. [*Master*: Mr. B. W. Adkin].
NEWMAN: Francis Winton; "Wolvesey," Poole Road, Parkstone, R.S.O., near Bournemouth [*Master*: Mr. S. J. Newman*].
NEWMAN: Henry Arthur; "Wolvesey," Poole Road, Parkstone, R.S.O., near Bournemouth [*Master*: Mr. S. J. Newman*].
PARRY: Albert Edward; 137, High Road, Balham, S.W. [*Masters*: Messrs. Albert W. Parry & Son].
PEVERILL: William Frederick; 17, Kempson Road, Harwood Road, Walham Green, S.W. [*Master*: Mr. Arthur Cates*].
PICKUP: Arthur; 33, Park Avenue, Blackburn, Lancashire [*Masters*: Messrs. Stones* & Gradwell].
PLOWMAN: Arthur Robert; 76, Lebanon Gardens, Wandsworth, S.W. [*Masters*: Messrs. Cole & Mansergh].
POLEY: Percy Charles; Willowbank, Hampton Hill, Middlesex [Hampton Grammar School].
PRICHARD: Walter John; 81A, Edmund Street, Birmingham [*Master*: Mr. C. E. Bateman*].
PROCTER: Basil; 2, Otterburn Villas, Newcastle-on-Tyne [*Master*: Mr. F. W. Rich].
ROBERTS; John Rowland; 95, Ashted Row, Birmingham [*Master*: Mr. D. Arkell].
ROBERTS: Reuben; 35, City Road, Chester [*Masters*: Messrs. T. M. Lockwood* & Sons].
ROBINSON: Thomas Henson; Home Cottage, Crabtree, Pitsmoor, Sheffield [*Masters*: Messrs. Flockton* & Gibbs*].
RODWAY: Ernest George; 6, St. John's Terrace, Weston-super-Mare [*Master*: Mr. H. D. Bryan].
ROYLE: John Bedward; Hough Green House, Chester [*Masters*: Messrs. Willink* & Thicknesse].
SALMON: Nathan Thomas; 21, Castle Street, Reading [*Master*: Mr. W. G. Millar].
SCHOFIELD: William Peel; 3, De Grey Terrace, Woodhouse Lane, Leeds [*Masters*: Messrs. Howdill & Howdill*].
SHEPHEARD: Thomas Faulkner; 136, Lloyd Street, Greenheys, Manchester [*Masters*: Messrs. Goldsmith & Son].
SHEPHERD: Ernest Edward; 37, Eldon Street, Newcastle-on-Tyne [*Masters*: Messrs. Plummer* & Burrell].
SMITH: Peter Chalmers; 4, Mount Street West, Aberdeen [*Master*: Mr. Alexander Smith].
SOMERSIDE: Robert James; 84, Great Hamilton Street, Glasgow [*Masters*: Messrs. W. J. Anderson* & A. N. Paterson, M.A.*].
SUTTON: Charles Ernest Burgett; Bank Villas, Great Sankey, near Warrington [*Master*: Mr. Wm. Owen*].
TABBERER: Francis Edward; The Holt, Leicester [*Masters*: Messrs. R. J.* & J. Goodacre*].
TANNER: Henry, jun.; Rothbury, Brackley Road, Beckenham [*Master*: Mr. Henry Tanner*].
TODD: William; 1, Hillsborough Square, Hillhead, Glasgow [*Master*: Mr. J. Thomson*].
TUCKER: Walter Stephen; 7, Radnor Terrace, Glasgow [*Masters*: Messrs. J. Salmon & Son*].
VENABLES: Arthur Bertie; 31, Prebend Gardens, Chiswick [*Master*: Mr. F. W. Roper*].
WATKINS: William Henry; Summerhill, St. George, Bristol [*Master*: Mr. F. Bligh Bond*].
WATSON: George; Walnut Cottage, Ruthrieston, Aberdeen [*Masters*: Messrs. Matthews & Mackenzie].
WHEELER: Frederick Christopher; Fernside House, Horsham, Sussex [*Master*: Mr. F. Wheeler*].
WIDDOWS: George Henry; c/o Mr. W. G. Penty, Clifford Chambers, York [*Master*: Mr. W. G. Penty*].
WILES: Joseph Gilbert; 1, Sion Villas, Kew Road, Richmond, Surrey [*Master*: Mr. F. J. Brewer*].
WOOD; Arthur Phillip Lomax; c/o Messrs. Grayson & Ould, 31, James Street, Liverpool [*Masters*: Messrs. Grayson* & Ould].
WOODHOUSE: Alfred Ernest; 10, College Road, Windermere [*Master*: Mr. Robert Walker*].
WRIGHT: Gordon Lorimer; 14, Belhaven Terrace, Kelvinside, Glasgow [*Masters*: Messrs. Burnet*, Son* & Campbell].
YOUNG: Clyde Francis; Ingleside, Oakhill Road, Putney, S.W. [*Master*: Mr. William Young*].

The asterisk * denotes a member of the Institute.

The Twelfth General Meeting.

The Meeting of the 22nd inst., for the reading and discussion of Papers on the Use and Abuse of Marble for Decorative Purposes, was held under the management of the Art Standing Committee;

but unfortunately Mr. Caröe, the Senior Hon. Secretary of that Committee, was unavoidably detained in Devonshire, and could not attend to direct the arrangements. Professor Aitchison lent several of his water-colour drawings, and others executed by the late W. W. Deane were kindly lent by his widow. Mr. Young's views of the interior of the Municipal Buildings of Glasgow, of Gosford House, and of other buildings, in which he had used marble to a very large extent, were hung around the Meeting-room. Messrs. Burke & Co., at the request of Professor Aitchison, sent some specimens, and Messrs. Farmer & Brindley also contributed a large collection of beautiful marbles. The reading of the Papers and the exhibition by limelight of Mr. Young's views occupied almost the whole of the usual two hours, and no time remained for the general discussion which had been contemplated. It may interest those who are now discussing in the JOURNAL the question of "Sound in its relation to Buildings" to know that the huge white cloth for the limelight exhibition had a perceptible effect on the voices of the speakers, who could not be heard even at a short distance—though under ordinary circumstances the Meeting-room, which is almost a square, is acoustically good.

A new Chair of Architecture.

The following is an extract from the report of a meeting of the Governors of the Glasgow and West of Scotland Technical College, held 17th inst.:—The Conveners of the Teaching and Staff Committee directed attention to the success of the courses in Architecture and Building Construction conducted by Mr. Gourlay [*A.*], and suggested the desirability of both recognising this success and strengthening the department by raising the lectureship into a professorship. On it being intimated that Mr. Gourlay was willing to devote his whole time to the work of the department, and to conduct day classes in architecture, it was unanimously agreed to recommend the Governors to create a Chair of Architecture and Building Construction, and to appoint Mr. Gourlay as its first occupant. The minute was approved; and if it be permissible to make any observation upon so welcome a piece of news, an inquiry may be raised as to the propriety of dividing Architecture and building construction with a copulative conjunction. Is not building construction a part of Architecture? If not, what is meant by Architecture? Is it merely a matter of design or composition, and draughtsmanship? And do not the technicalities of building construction—in other words, the details of constructive science—form an indispensable part of an architect's functions?

J. B. Papworth and Sir M. Digby Wyatt.

Two small framed drawings have been recently received—the work of J. B. Papworth (the father of Woody Papworth and Wyatt Papworth) and of Matthew Digby Wyatt. The first named—an interior, in Indian ink, of a chapel—was left by Wyatt Papworth, who, in his will, offered it as a gift from him in memory of his father; the second is a coloured interior of the Church of San Benedetto, Subiaco, drawn by Sir Digby, and presented as a souvenir of him by his nephew, Mr. T. H. Wyatt [*H.A.*]. Both have been hung in the Council-room.

The late Arthur Lett [*F.*].

Mr. Arthur Lett, whose death was announced at the General Meeting of the 25th February, was born 25th March 1846. He became an Associate of the Institute in 1867 and a Fellow in 1892. Mr. Lett's principal architectural works include the St. Lawrence Institute, Kilburn, several blocks of flats for private investors, and many warehouses in and around London. He had the superintendence of the extensive alterations necessary to fit the old Soho Bazaar for the publishers Messrs. Adam & Charles Black, when they transferred their business from Edinburgh to London. Mr. Lett had also the management of many important estates, and he laid out several large estates in the north and south of London, including the Dulwich House Estate for the trustees of the late Mr. Thomas Lett, and for several companies and private clients.

International Sanitary Exhibition in Paris.

It appears that the house drainage of Paris is to be re-arranged in the course of the next three years on a plan similar to that now generally adopted in England; and so the Parisians, taking time by the forelock, are organising an International Sanitary Exhibition to be held in what was once the Champ de Mars, at the Palais des Arts Libéraux, from the 1st June to the 15th September of the current year. In the business-like circular by which the coming Exhibition is announced to the world, the promoters state that owing to the new law, which is to revolutionise the sanitary arrangements of Paris, "there will be "a great demand for approved forms of sanitary "apparatus," and that the Exhibition affords "a "good opportunity for those manufacturers in "England who wish to place their goods on the "French market." The exhibits are to be divided into ten classes: (1) Hygiene of Dwellings (to which, it may be assumed, architects' drawings will be admitted); (2) Municipal Hygiene; (3) Prevention of Infection (influenza, it is to be hoped, to be classed herein as an infectious disease which may be avoided or checked like cholera and typhoid); (4) Demography and Sanitary Statistics; (5) Sanitary Science; (6) Hygiene applied to Infancy; (7) Industrial and Professional Sanitation; (8) Alimentary Hygiene; (9) Hygienic Clothing; and (10) Physical Exercises.

The Special Commissioner of the English section is M. Maurice Pérèz, Sanitary Engineer. Among the "Committee of Directors" are two Hon. Corresponding Members of the Institute: M. Achille Hermant, who is a Vice-President; and M. Émile Trélat. Among the "English "Committee of Patrons" are Sir Robert Rawlinson, President of the Institution of Civil Engineers; Sir Henry W. Acland; Mr. Binnie, the Engineer-in-chief of the London County Council; Professor Corfield; Sir Douglas Galton; Sir Philip Magnus; and Mr. Shirley J. Murphy. The offices of the administration and direction are at 103 Boulevard Haussmann, Paris.

Additions to the Library.

From Messrs. Longmans, Green & Co. has been received a new edition of *The Ruined Cities of Mashonaland*, being a record of Excavation and Exploration in 1891, by J. Theodore Bent, F.S.A., F.R.G.S. Recent excavations, and the numerous ruins brought to light in opening up the country, have provided the author with a mass of fresh material, the most interesting points of which have been embodied in the new edition. Mr. R. M. W. Swan contributes to the work a chapter on the Orientation and Measurements of the Zimbabwe Temples. The illustrations are numerous and excellent.

Two elementary text-books on mechanics, recently added to the Physical Series of the Cambridge Natural Science Manuals—viz. *Statics* and *Dynamics*, by R. T. Glazebrook, M.A., F.R.S.—have been presented by the Syndics of the Cambridge University Press. The subjects are treated both from a practical and a theoretical point of view. Messrs. E. & F. N. Spon have presented their *Engineers' and Contractors' Illustrated Book of Prices for* 1895–96.

Donations from members include from Mr. Henry Lovegrove [*A.*] a Third Edition of the great work, in two volumes, by Francesco Milizia, entitled *Memorie degli Architetti Antichi e Moderni*, published at Parma in 1781; from Mr. E. W. Wimperis [*A.*], for the Loan Collection, *The Soil in relation to Health*, by H. A. Miers, M.A., and R. Crosskey, M.A.; from Mr. John Holden [*F.*], a Catalogue of the Loan and Reference Library of the Manchester Society of Architects; and from Mr. F. M. Gratton [*F.*], a bronze replica of the Shanghai Municipal Jubilee Medal designed by him.

Among the purchases are J. H. Parker's *Introduction to the Study of Gothic Architecture* (Oxford, 1849); *The Englishman's House*, by C. J. Richardson (Lond. 1870); Gwilt's *Rudiments of Architecture*, 2nd edition (Lond. 1839); Smith & Porcher's *Discoveries at Cyrene* (Lond. 1864); S. Riou's *The Orders of Architecture* (Lond. 1768); J. Van Campen's *Stadthuys van Amsterdam* (Amsterdam, 1664); and an Album of Photographic Views of various parts of Helmingham Hall and Church.

Herr Ferdinand Fellner, of Vienna, has presented a portfolio containing a large collection of prints and photographs of theatres erected from the designs of his firm in various parts of Austria, plans, elevations, and sections being given of most of the buildings. A collection of photographs has also been presented by Herr Alexander Wielemans, of the same city, comprising views, exterior and interior, of buildings and monuments carried out by him, and specimens of some exquisite cabinets and other articles made from his designs.

Erratum.—In the obituary notice of Mr. H. A. Gregg, at p. 379, the date of his election as Associate should have been 1887, not 1877 as there printed.

REVIEWS. XXIV.

(71.)

PERSPECTIVE FOR ARCHITECTS.*

Architectural Perspective: the Whole Course and Operation of the Draughtsman in Drawing a Large House in Linear Perspective. Illustrated by numerous Progressive Diagrams, Bird's-eye and other Views of a House, Views of Interiors, &c. With Hints on Pen-and-ink Drawing. By F. O. Ferguson, Architect and Surveyor. Second Edition, revised, with additional illustrations. 8o. Lond. 1895. Price 3s. 6d. [Messrs. Crosby Lockwood & Son, 7, Stationers' Hall Court, E.C.]

When a book has once run the gauntlet of criticism, and attained the dignity of a second edition, the reviewer is inclined to think that it has passed beyond the reach of praise and blame, that nothing remains for him to do save to point out the improvements which have been made in the new edition and to dismiss the book with a careless word of praise. The copy of Mr. Ferguson's *Architectural Perspective* which lies before me is the "second edition, revised, with additional "illustrations," and the usual thought arises that criticism is unnecessary. But a perusal of the book reveals imperfections; and, for the sake of the young student for whom the book is intended, these ought not to pass unmentioned. In the note to this edition we are told that "it will be "found materially improved by the addition of "three new plates . . . and of a new Fig.," and that "a few corrections have also been made." Naturally enough the reader turns first to the new plates. The first of these is Plate 4, described "Pen-and-ink drawing." As a perspective drawing little or no fault can be found with it; as an

* See Mr. E. Ingress Bell's review of the first edition in THE R.I.B.A. JOURNAL, Vol. VIII. N.S. p. 119.

example of black and white, however, it is not so successful. The draughtsman is evidently more at home with his ruling pen than with the ordinary nib. The drawing, nevertheless, is a considerable improvement on the older drawing, Plate 3. So also is Plate 5, notwithstanding the Lilliputian tennis-net, and the somewhat haphazard manner in which the shadows are projected. The third new plate, 7, is the least laboured and the most successful, but is marred by the incorrect drawing of the panelled soffits of the four main arches. If the author had only thought of his own Rule IV.—and this ought not to have been a difficult matter after his instruction on page 29: "Keep Rule IV. well in mind"—he would not have been guilty of this error.

Little need be said about the older part of the book. The author's method of teaching perspective is extremely simple and clear, and will commend itself to the very young student. Nothing, however, is said as to the greatest angle which can correctly be included in the view; this omission will undoubtedly lead the student to bewail a distorted perspective sooner or later. So also, but in a greater degree, will the author's unsystematic disposal of the picture-plane: this ought to be at right angles to a line bisecting the angle of vision, but it never is in Mr. Ferguson's book. Again, the picture plane is here invariably shown touching the salient angle of the buildings: this method has the merit of simplicity, but it ought to have been explained how, by advancing or withdrawing the picture-plane, a larger or smaller drawing could have been obtained from the same plan. The complications arising from the use of only one height-line have not induced Mr. Ferguson to explain the method of obtaining others, and the application of the ellipse in drawing arches and circles in perspective is not illustrated. What Mr. Ferguson means by Rule VI. I really cannot say; how a *side* (of a bay) can be parallel to a *point* passes my comprehension. It is to be regretted that Mr. Ferguson and his publishers have not seen fit to take advantage of more of the corrections and emendations suggested in these and other columns on the first appearance of the book. This edition is an improvement on the first, but it might have been better. G. L. SUTCLIFFE.

(72.)

SAFE BUILDING.

Safe Building: a Treatise giving in the simplest forms possible the Practical and Theoretical Rules and Formulæ used in the Construction of Buildings. By Louis de Coppet Berg, F.A.I.A., Member American Society of Civil Engineers. 2 *vols. La.* 8o. *Boston,* 1892. *Price,* £2. 2*s. net.* [*Messrs. Ticknor & Co.,* 211, *Tremont Street, Boston, U.S.A.; Messrs. Macmillan & Co., Bedford Street, Covent Garden, London.*]

This book is not, as might be supposed from its title, about the building of safes, but of ordinary structures in a stable manner. One of the sentences of the Introduction raises an important question:—

> While, of course, the work will be based strictly on the science of mechanics, all useless theory will be avoided. The object will be to make the articles simply practical. To follow any of the mathematical demonstrations, arithmetic and a *rudimentary* knowledge of algebra and plane geometry will be sufficient.

An architect's mere elementary knowledge of these subjects is to be deprecated, and it is questionable whether such superficial qualification is sufficient to solve the more abstruse questions of applied mechanics. There is very little doubt that boldness of conception is frequently restrained by the architect's ignorance in this direction, and as a consequence it has been reserved for the nineteenth century to furnish that curious product of modern practice—the architect's engineer. "We "are mere operatives, empirics, and egotists until "we learn to think in letters instead of figures."

Some of the author's statements are distinguished by their artlessness. For instance: "Cements or limes that will set under water are "called hydraulic."

The arrangement of the book, by which advice on the art of building is mixed with the formulæ, is perhaps hardly so convenient as the ordinary practice of keeping the subjects separate, of which latter course Gwilt's *Encyclopædia* and Rivington's *Building Construction* are admirable examples. From the last-named work some quotations are given in this book.

As might be expected in an American work, iron and steel construction are prominent features, but we find no mention of the expedient adopted in American cities for the foundations of their very high buildings—a grillage of iron and concrete; nor to the steel frames, which form so large a part of their enclosing walls. Nor do we find any allusion to the newest theories of wind-pressure on buildings, which may be expected to materially modify the existing ones.

In the section relating to tall chimneys, Portland cement mortar appears to be recommended; lime mortar is usually preferred; and the common practice of building a detached fire-brick lining for a certain distance above the base is not mentioned.

Most of the usual expedients of good building are described, and it is, of course, not the writer's fault that they are familiar. One piece of good advice, probably derived from an experience of tall buildings, is as follows:—

> In all walls try to get all openings immediately over each other. A rule of every architect should be to make an elevation of *every* interior wall, as well as of the exterior walls, to see that openings come over each other.

The uniform use of the same letter to express a particular meaning in the whole of the various

formulæ is a sensible practice. There is rather more information in the tables as to the transverse strength of stones than appears in our English text-books; but it is, nevertheless, meagre, and mostly relates to American stone.

On the whole the *original* information is essentially American, as in the table of brands of iron and the frequent reference to Georgia pine—seldom used in this country. It is consequently of small use to the English student of building; a remark which applies to the valuable works of Trautwine and some other American authors of technical books.

Subject to the foregoing strictures, this work evinces great care and pains, is sensibly and clearly arranged, and, as might be expected, is worthy of the reputation of the publishers.

JOHN LEANING.

NOTES, QUERIES, AND REPLIES.

Sound in its Relation to Buildings [p. 353].

From Professor AITCHISON [*F.*], A.R.A.—

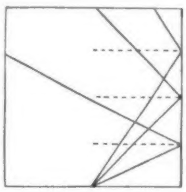
In my remarks [p. 372] I spoke of the brazen vases found in theatres mentioned in the *Classical Museum*. It is, perhaps, as well to give the place and particulars. They are referred to in *A Description of some important Theatres and other remains in Crete from a MS. History of Candia. By Onorio Belli in* 1586. Being a supplement to *The Museum of Classical Antiquities*, by E. Falkener. 8vo. London, 1854. The date of Onorio Belli's letters is 1586: he died in 1604. At page 13, speaking of the larger theatre at Hierapytna, Onorio Belli says:—"The theatre has "at least one row of bronze *echeia*, the cells of "which are very visible." In the theatre of Lyttus "there were three rows of brazen vases "(*echeia*) in this theatre, almost all the cells of "which are still visible" (page 19).

From Mr. FALKENER—

Buildings as connected with sound may be divided into two classes: Those intended for music, and those used for lectures and public speaking. Not being a musician, I can say nothing about the former, except to express my surprise and delight to hear that music requires a building to be in harmonic relation with it, in its proportions and material, as we find in the violin.

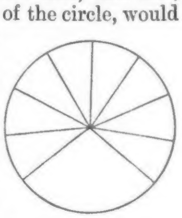
As regards buildings for public speaking and lecturing, I cannot help thinking that much that has been said about the acoustic properties of several forms of buildings proceeds from fancy rather than reality: for we find opposite opinions held in nearly every case. In buildings for such purposes we have to consider principally, not so much the faint echo which comes back to the speaker at the end of a long room, as the power of a speaker at one end of a room to make himself heard at the further end. If a speaker knows that those at the further end of a room can hear him, he will not trouble himself at the faint sound which reaches his ear, if he listens to it, when it is drowned by the loud sound of his own voice; and if he speaks in a low voice he will hear no echo at all. Echo, therefore, and the power of hearing should be considered separately.

The square, and especially the cube, has been pronounced the worst form for acoustics. I have been in some of the committee-rooms of the Houses of Parliament when business has been going on—square rooms, with lofty ceilings approaching a cube—and I heard perfectly every word that was said, and was not sensible of any echo; and, indeed, how can there be when sounds reflected from the side walls can never return to the speaker? It is only the opposite wall that would bring back the sound, but that is so near that the echo, if any, would be the mere prolonging of a sound, as the note of an organ is distinguished from that of a piano; a softening and mellowing, which would be an assistance, if anything, to rough voices.



But the circle is pronounced to be still more vicious. It is said that at the London Colosseum, a building 130 feet in diameter, "a word is re-"peated a great many times; an exclamation is "like a peal of laughter, while the tearing of a "piece of paper is like the patter of hail"; and at the Dublin Rotunda a person said, "It appeared as "if someone were in front soaking up my words "with a sponge as soon as the syllables had left "my mouth."

No doubt, anyone standing in the centre of a circular building, and trying his voice, would have every sound proceeding from his mouth brought back to him from every inch in the circumference, and from each of these points there would be an echo if sufficiently far off, and a wonderful increase of sound under all circumstances; for each line of sound would return in the same line, and this, coming equally from all points of the circle, would have a stunning effect. But why should a person studying acoustics stand in the centre, instead of near the circumference? Again, the "whisper-"ing galleries" of St. Paul's and of St. Peter's at Rome are considered as evidence of acoustic defect. These are in galleries, where you are obliged to stand close to the wall, and you place your mouth against the wall, and direct your voice in the line you wish it to take; and the sound is held together along the



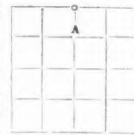
wall, not being able to escape, and so becomes increased in power. It is merely a child's plaything on a large scale. But in a large circular room you are no more obliged to stand whispering, with your mouth against the wall, than you were in standing in the centre of the room and shouting.

Instead of being a bad form, the circle, or rather the half-circle, is the very best form that can be used, when the speaker is sufficiently removed from it—as in the Greek theatre, where, all lines of sound from the speaker's mouth being reflected into the body of the theatre, no sound was lost. When we consider the enormous size of some of these theatres—that of Lyttus being 350 feet in internal diameter, and capable of holding 40,000 spectators—we must be convinced of the wonderful acoustic capability of such buildings; evidenced also by the twelve brazen vases, *echeia*, in each of the three precinctions, each of which took up a different note in music.

The principal cause of echo, then, is produced by a long room, where the further wall is so distant that the time occupied in the return wave is sufficient to produce a distinct repetition of the sound, which thus becomes an echo. It has been suggested that the side walls should be broken up by recesses, or projections, or drapery, in order to prevent the waves of sound from being reflected by the back wall. No doubt this would lessen the effect of echo; but then it would seriously affect the power of hearing, which would be still worse; for we all know how the power of the voice is increased when we speak in an empty room devoid of furniture. The more even the side walls are, the greater will be the power of hearing. The echo of the distant wall will be better destroyed by breaking it up with galleries, alcoves, or recesses. A long room, therefore, with deep recesses at the sides, is the most difficult to be heard in, as each of these recesses prevents the sound from going further. Few people, at the further end of the nave of a church, the side walls of which are broken up by deep windows, can hear the preacher, and this difficulty is still further increased when, in a large church, the pulpit is placed against a pier at the angle of the chancel and transept, instead of at angle of nave and transept, as in that case the walls of the transepts prevent many of the waves of sound from going further.

The power of hearing forwards, sideways, and backwards is in about the proportion of 3, 2, and 1;

the best proportions of a room therefore for hearing would be 4 × 3, in which case the speaker's seat being in the middle of the largest side, his voice would reach three squares in front, and two on each side; but as his seat would be against the wall, he would have the benefit of the back sound, which would be reflected forwards, and thus enable his voice to extend four squares forwards, instead of three; and it would thus become a square room, which is pronounced to be the worst form possible! This would be appropriate for a lecture-room; but in a court of justice, or place of meeting, the back part of the room would form a daïs; and the judge or chairman would have his seat at A, and his voice then would extend three squares forwards, two sideways, and one backwards, thus producing the same result.



We must be careful that we do not confuse the so-called "acoustic vases" found in some domes with the acoustic vases, *echeia*, already mentioned. I cannot conceive how such vases, when covered over with mortar and plastered on the outside, could be sonorous. Certainly the vases in the vault of an oven, of which I made a sketch in 1847, at Pompeii, were not intended for acoustic purposes. I believe they were only used for strength, lightness, and avoidance of thrust.

There are other things which have to be considered. For instance, much has been said about *echo*, and my remarks are principally directed to that subject; but echo, being the *distinct repetition* of a sound, is only one of the impediments of hearing; and for this a remedy may be found in the *form* of a room. But, on attending a Court of Petty Sessions yesterday, a room of correct proportions according to Vitruvius, I was struck with the difficulty of hearing. There were only two magistrates attending, owing to the season; and there were only two cases, and about half a dozen witnesses and police. The consequence was—the room not being large enough for an echo, and the walls and floor being quite bare—there was a confused *noise* or buzzing. This evil, therefore, has to be guarded against, as well as echo; and I have no doubt that the two evils are often spoken of as one and the same thing. But they are quite distinct; and I recommended that the room should be lined with felt, or battened and plastered, and the floor covered with matting; but I was told the County Council would not allow the expense. When the Court is full of people, this evil is not so apparent. This shows that in comparatively small rooms, when the walls are like "sounding boards" all round, you require the room to be full of people; or the floor carpeted, and the walls lined with pictures, and the windows with drapery. All this you cannot have, except in private houses; but with rooms devoted to public business the evil of *noise*, as contrasted with echo, is greatly remedied, and, indeed, becomes nugatory, by their being filled with people. A man standing in the centre of a circular room, when empty, and trying his voice, is quite opposed to this.

I omitted to mention—in speaking of the lines of voice from an actor in the Greek theatre being reflected in a different direction from every inch of the circumference—that not only no sound was

lost, but this circumstance of the constant divergence of the lines of sound *prevented the possibility of echo*, which was what they had to guard against.

From William White [*F.*], F.S.A.—

In order to obtain successful acoustic results for music-halls and other public buildings, it has been commonly considered that certain numerical ratios should be employed for determining the dimensions. But we must not rest content merely with the employment of arithmetic or progressive multiples of a given unit. This will become pedantic and misleading unless care be taken to choose only such as shall fall also—approximately at any rate—within simple principles of geometry, and shall bear really an intimate connection with geometric forms based upon the equilateral triangle and angles of 30°, 60°, and 120°, as opposed to 45°, 90°, and 135° (there being no such angle as 180°).

The worst of all possible proportions, whether æsthetically or acoustically, is the perfect cube. We must strive to avoid it, and get as far as possible away from it and its relations, which we may do by basing our proportions upon the equilateral triangle. For lecture-rooms, or for chamber music, my "model of proportion" is a parallelogram (figs. 1 and 1A), taking for its breadth the

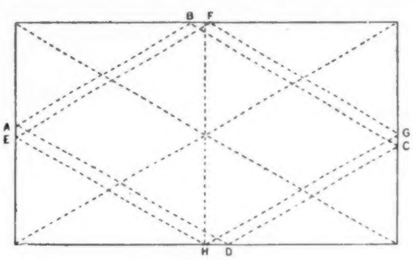


FIG. 1.

base of an equilateral triangle, whose perpendicular should give the height, and two perpendiculars its length. The numerical ratio for this would be 6·7·12, within a trifling fraction, as shown at *e*, *f*, on fig. 2. One property of this proportion is that a succession of equal or reflecting angles, taken from any point on end or side, would then, as it were, be such as might be repeated concurrently all round the room, as shown on fig. 1 at *a*, *b*, *c*, *d*, *a* and *h*, *e*, *f*, *g*, *h*. The same coincidences would not occur or apply in the same manner in rooms of other proportions, nor with other angles.

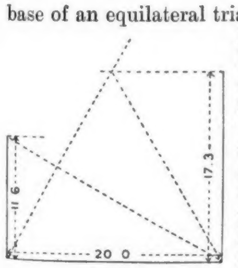


FIG. 1A.

According to the size and purposes required, I should employ reduplications or subdivisions of my "model" for all the dimensions of the room, thus bringing all more or less into some sort of recurrent harmony. But for a music-hall, for orchestral music, or for the organ, I should give a greater dimension to the height instead of the breadth of the room.

In selecting a numerical ratio it might seem perhaps at first sight that there could be but very

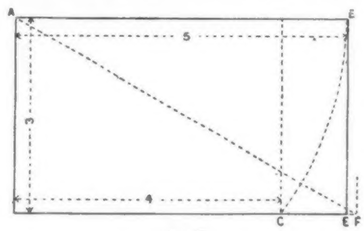


FIG. 2.

little to choose; for instance, between 3·4·5 and 4·5·6. But the 3·4·5 really is the proportion of a parallelogram whose sides and diagonal have a simple harmonic ratio to each other; thus, $3^2+4^2=5^2$. This is not so with 4·5·6, for $4^2+5^2=41$, instead of 36, or 6^2. Moreover, in 3·4·5 (fig. 2) we have not only the harmonic ratio of $a, c = a, e$, but also, excepting the small fraction *e* to *f*, we have an intimate relation with the double equilateral triangle, shown on fig. 1, which is wholly absent from 4·5·6 (fig. 3), the harmonic lines *a*, *b*, *c* and *a*, *f* here falling considerably outside it.

Three of the instances given in Mr. Burrows's Paper as successful are as 2·3·5. Here the principal relation is the same (as in fig. 2) of 3 to 5, whilst the 2 is just half of the 4. But to harmonise accurately with the triangular proportions

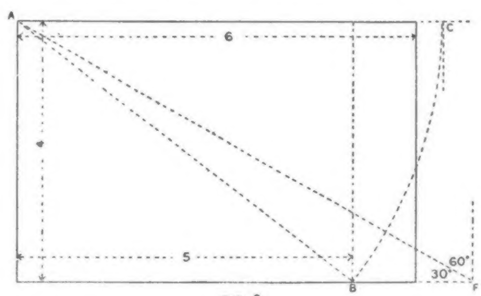


FIG. 3.

this ratio should be as $1\frac{3}{4}\cdot3\cdot5\frac{1}{4}$, instead of the 2·3·5.

Then I would instance a class-room which is so distinctly bad for sound as to be a serious inconvenience. If the ceiling were 15 inches lower its ratio would be as of 3·5·7. It is 28 feet long by

20 feet wide (or 7 to 5), and 12 feet 9 inches high. The length is as nearly as possible that of the diagonal of the square of the width, but it is very far away from all relation to the triangular system as shown in the plan (fig. 4) and section (fig. 5). An echo may arise from various causes, but I believe it may be produced by the abrupt interception of the waves of sound against a plain wall or ceiling reflected back in a direct line upon the speaker, instead of their being transmitted, from nearer points of contact, through harmonic angles of reflection. And, whatever may be the treatment of form, material, or construction to moderate or to modulate resonance, some harmonic system of proportion ought in all cases to be observed, for what purpose soever the building may be required, whether for music or for reading and speaking.

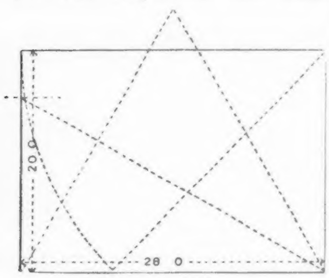


FIG. 4.—PLAN.

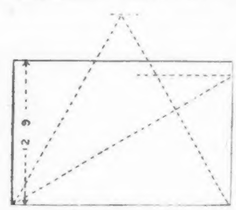


FIG. 5.—SECTION.

An echoing room for music might give an agreeable fulness to the sound, but at the sacrifice of that distinctness of note for which the musical ear craves, and which can be obtained only through making the proportions of the room in some sort sympathetic with the harmonic principles of music. These principles, so far as they have been crystallised in the chromatic scale agreed upon by musical experts, were fixed at last definitely by consensus of opinion after long deliberation and experiment. And the progressive ratio is very far from that of simple arithmetic. An octave of the number of vibrations in a second, forming the pitch of each note respectively, is here given, taking the medium pitch of 528 vibrations for " C " in the third space of treble, for the numerical increase on each respectively.

Number of Vibrations in a second.

247 ‖	264	297	330	352	396	440	495	528 ‖	597
	C	D	E	F	G	A	B	C	

Rate of numerical increase in each.

‖ 17	33	33	22	44	44	55	33 ‖	(69)

This, in the main, seems to agree with our equilateral progression of 3·4·5. And the number of vibrations in F and G (the upper note of the 5th in the scale), being 352 and 396, are in the exact ratio of the perpendicular to the base of an equilateral triangle.

Whether this view of the principles which exist in common between music and architectural proportions be accepted as correct or not, it is quite certain that there is a wonderful and very beautiful connection between form and musical sounds, as seen in the operation of the phonograph; as also in the elaborate forms of the geometric gyrations of strings vibrated in musical chords, which greatly encouraged me in my investigations.

From Max Clarke [*A.*]—

In my opinion any simple table giving the sizes of halls, and then taking these sizes and saying that the proportions are such and such, is so much waste material, as it is impossible to deal with the subject without giving the full particulars of each hall, such as the following :—

Length : where it is taken to at each end.

Breadth : whether the dimension is taken, say, from wall to wall on the ground floor, and if this wall is carried up vertically; also whether the side walls are parallel.

Height : whether the dimension is the same throughout the length given. Whether the ceiling is a flat surface or coffered. If arched, what is the section.

Further, the number of galleries; their projection from the walls; if close together, enough to form the major reflecting surface, and what shape on plan.

It would also be necessary to give the material with which the walls are covered, the construction of galleries and ceiling, whether all are resonant, such as wood lining; hard reflecting, such as plaster; or absorbent, such as hangings and the like.

There is ample scope for any *dilettante* architect who wants to do the profession a real service with regard to sound in relation to buildings, who would take the matter up and make a detailed description of each public hall of any note, giving their acoustic *reputation* both for speaking and music (for this is the only word which, to my mind, can be used), and following with details of size, shape, and construction so far as it would affect sound.

Below are a few particulars of halls which have not been specially mentioned :—

The large hall of the Public Halls, Glasgow, built by Mr. Campbell Douglas, of which two photographs were exhibited at the meeting. A very good hall, I believe, for sound. Length, 180 feet; width, 76 feet; height, 56 feet.* One balcony. The building has square terminations at each end. No cove or the like in cornice, flat coffered ceiling—in fact, a general squareness necessary to fall in with the somewhat severe style of architecture adopted.

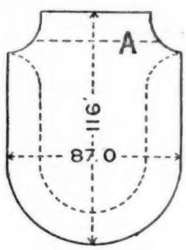
St. James's Hall, London :—Good for sound. Length, 139 feet; width, 59 feet; height, 59 feet

* *The British Architect*, 1880.

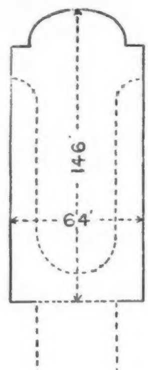
6 inches.* The proportion does not fall in with any of the ratios given in the Paper.

Leinster Hall, Dublin:—Very good for sound. Length, 146 feet; width, 64 feet; height, 52 feet. Orchestra end curved; one balcony; ceiling flat, with coved cornice; walls all plastered.

Queen's Hall, London:—Very good for sound. Length, 116 feet to back of orchestra; width, 87 feet; height, 57 feet. Two balconies.



QUEEN'S HALL.



LEINSTER HALL, DUBLIN.

In the Queen's Hall the organ takes up a great portion of the recess forming the orchestra (what Mr. Burrows terms a truncated trumpet-shaped orchestra), although the orchestra platforms are continued under the organ, which extends to the dotted line A on the small sketch-plan; consequently the major reflecting portion or general outline of the hall is bounded by the line A, so doing away with any advantage which might be gained by the particular form mentioned.

The walls are boarded, canvassed, lined with lining paper, and covered with a stamped paper. The ceiling is fibrous plaster, very slightly convex, with a sloping portion all round, also slightly convex.

I think I am correct in stating that the ceiling of the Alhambra Theatre, London, is fibrous plaster; the concrete which has been mentioned forms the outer roof.

The Pamphlet of Subjects for Prizes and Studentships, and Members in the Colonies.

From R. M. Hamilton [*A.*], Christchurch, N.Z.—

I see that in the Kalendar the Almanac of Proceedings runs from November 1894 to October 1895. We received it in New Zealand early in January 1895. Looking through the Prizes and Studentships on pp. 264–279, I see "The Essay "Medal" (open to British subjects under forty). The subject this year interested me: "The In- "fluence of Literature on Architectural Develop- "ment." I look at the Conditions, and find the Essay must be sent to the Institute before 24th December 1894. I admit that not often would it be possible for members living in "Greater Britain" to be able to compete in the Studentships, but the subject of the Essay of 1894 is capable of being dealt with by those in the outlying portions of the Empire, though the "General Conditions" debar this. If the subjects could be notified earlier in the year to those interested, or the Kalendar issued to those farthest away first, there might be a possibility for any British subject to compete in some of them. Englishmen do not recognise how rapidly, with the frequent communication to all parts of the globe, the outskirts of civilisation (British) are becoming suburbs of London. The colonies know more of England generally, and of what is going on there, than England knows of its colonies, for each colony is looking inward to the mother country, while she has to look outward all round.

From William H. White [*F.*]—

Mr. R. M. Hamilton, who qualified for the Associateship in 1884, and who expresses towards the mother country sentiments prevailing in the minds of all colonial gentlemen, is perfectly right in his contention generally. But he has made a natural mistake in supposing that the section of the Kalendar 1894-95 devoted to "Prizes and Stu- "dentships" is the first announcement of those offered to competition in 1894. It is merely the reprint of a pamphlet published in March 1894, which pamphlet was obtainable at the office of the Institute by all members who chose to ask for it, either personally or in writing; and it was sold to outsiders for threepence, exclusive of postage. Obviously, members in New Zealand were quite unable to take advantage of this, even if they had known it; and though the particular List of Subjects for Prizes and Studentships to which Mr. Hamilton refers was given in the Journal [Vol. I. p. 380] on 12th April 1894, he would not receive the quarterly part containing it until August. It seems, therefore, desirable to publish the Prizes and Studentships Pamphlet as soon after the month of January (when the Presentation of the former year's Prizes takes place) as possible—say the first week in February. If this were done, and the pamphlet issued to every member of the Institute as soon as published, the very just remonstrance made by Mr. Hamilton, and several others in distant parts of the Empire, would be met—and at relatively small cost to the Institute.

"Notes upon the Architecture of China" [p. 37].

From F. M. Gratton [*F.*], Shanghai—

I venture to draw attention to an error which has occurred on page 50 of the current volume of the Journal, in which fig. 6 of the illustrations in my "Notes upon the Architecture of China" is described as the "Fokien Guild at Ningpo." This should be "Fig. 6. Plan of the Bankers' Guild "at Shanghai."

* *Building News*, 2 July 1880.

MINUTES. XII.

At the Twelfth General Meeting (Ordinary) of the Session, held on Monday, 22nd April 1895, at 8 p.m., Mr. F. C. Penrose, F.R.S., *President*, in the Chair, with 28 Fellows (including 14 members of the Council), 18 Associates, 3 Hon. Associates, and 25 visitors, the Minutes of the Meeting held 25th March [p. 393] were taken as read and signed as correct.

The decease was announced of the following Associates—viz., John George Hall, Gordon Macdonald Hills, and Alfred Hayles Clark.

The President announced the results of the Final Examination held in London and Manchester from the 29th March to the 5th April, and read the names and addresses of 26 persons who had qualified for candidature as Associate [p. 417].

The President further announced the results of the Preliminary Examination held in London, Bristol, and Manchester on the 19th and 20th March 1895, and read the names of 114 persons who had been registered as Probationers [p. 418].

The following Associates, attending for the first time since their election, were formally admitted, and signed the Register—namely, Henry James Wise, George Patrick Sheridan, Charles Henry Smith, and Vivian Herbert King.

Papers on The Use and Abuse of Marble for Decorative Purposes, by Professor Aitchison [*F.*], A.R.A., William Young [*F.*], and W. Brindley, F.G.S., having been read by the authors, a Vote of Thanks was passed to them by acclamation, and the Meeting separated at 10 p.m.

The Birmingham Association.

The following are the Officers and Council for the year 1895-96, elected at the Annual Meeting on the 22nd March:—President, Mr. Wm. Henman [*F.*]; Vice-President, Mr. W. H. Bidlake, M.A. [*A.*]; Council, Messrs. J. A. Cossins, W. Hale [*F.*], H. R. Lloyd [*A.*], F. Barry Peacock, E. C. Bewlay, A. Hale [*A.*], and J. A. Swan; Hon. Treasurer, Mr. A. Harrison; Hon. Librarian, Mr. C. Silk; Auditors, Messrs. A. T. Powell and E. Hale; Hon. Secretaries, Messrs. Herbert T. Buckland and Charles E. Bateman [*A.*].

The Nottingham Society.

The Annual Meeting was held on the 3rd April, when the Officers and Council for the year 1895-96 were elected as follows:—President, Mr. John Howitt [*F.*]; Vice-President, Mr. A. N. Bromley [*F.*]; Council, Messrs. A. R. Calvert, A. H. Goodall, W. D. Pratt, H. Walker [*F.*], and F. B. Lewis [*A.*]; Auditors, Messrs. A. W. Brewill [*F.*] and John Sander; Hon. Secretary and Treasurer, Mr. A. Ernest Heazell.

The Leeds and Yorkshire Society.

The Annual Meeting was held on the 8th April, when the Officers and Council for the year 1895-96 were elected as follows:—President, Mr. E. J. Dodgshun [*F.*]; Vice-Presidents, Messrs. W. Watson (Wakefield) and W. Carby Hall [*A.*]; Hon. Treasurer, Mr. W. H. Thorp [*F.*]; Hon. Librarian, Mr. W. H. Beevers [*A.*]; Hon. Secretary, Mr. F. W. Bedford [*A.*]; Members of Council, Messrs. W. S. Braithwaite, H. B. Buckley, G. F. Danby, W. A. Hobson, Jas. Ledingham [*F.*] (Bradford), and W. C. Williams [*F.*] (Halifax); Auditors, Messrs. H. S. Chorley, B.A., and L. S. Dodgshun.

The Sheffield Society.

The following is a list of the Officers and Council for the year 1895-96, elected on the 9th April:—President, Mr. Charles Hadfield [*F.*]; Vice-President, Mr. R. W. Fowler; Treasurer, Mr. F. Fowler; Hon. Secretary, Mr. C. J. Innocent [*F.*]; Council, Messrs. T. J. Flockton [*F.*], E. M. Gibbs [*F.*], T. Winder, J. Smith, W. H. Lancashire, H. W. Lockwood, and W. C. Fenton.

PROCEEDINGS OF ALLIED SOCIETIES.

THE NORTHERN ASSOCIATION.

Theoretical and Practical Notes on Beams, Columns, and Roof Trusses. By J. M. Moncrieff, Assoc.M. Inst.C.E.

Read before the Association at Newcastle, 13th March 1895.

I cannot pretend to lay before you an attractive or fascinating subject this evening, at least as viewed from the standpoint of the students of art. I hope, however, that the few notes which I am about to read may be useful, at any rate to the junior members of your Association. The subjects of the Paper are "Beams, Columns, and Roof "Trusses," but my notes are not in any sense to be considered as dealing with these subjects in a general way, but only on certain particular lines. In consequence, the Paper is a fragmentary one and somewhat disconnected.

At the risk of giving superfluous information, I may say that in considering the effect of bending moments the apparent maximum tensile or compressive stress is generally designated by the letter f, and I shall follow the usual custom in my remarks, with the exception that in dealing with the transverse strength of *timber* it will perhaps be more convenient to make use of the coefficient of ultimate transverse strength, which is frequently symbolised by the letter κ; as, for instance, in the common formula for a beam loaded at the centre, and supported at both ends, where the

$$\text{breaking weight} = \frac{4\kappa b d^2}{l},$$

the length and scantlings all being measured in inches.

I propose to direct your attention, in the first place, to beams of *brickwork*. Brick in cement can be made into beams of somewhat surprising strength, and to illustrate this I may quote some old experiments described by General Pasley many years ago.* These experiments were, among many others, made in 1830 in connection with some military buildings at Chatham, and the cement used was made under General Pasley's instructions. The experiments were made as follows:—

A brick having its length horizontal was attached by neat cement mortar to the vertical face of a brick wall (fig. 1), the cement being well compressed in applying the brick. To this brick was added another in the same manner until eight bricks were in place. The cement set so quickly that not more than six or seven minutes intervened between the fixing of one brick and the following one. These eight bricks stood for twenty-four hours, and then four more were added, making a solid cantilever weighing $73\frac{1}{4}$ lbs., and projecting 2 feet $11\frac{1}{4}$ inches from the wall, nearly 9 inches in width and $4\frac{1}{2}$ inches in depth. On adding a thirteenth brick the mass broke down. Other experiments made at the same time gave similar results.

Similar experiments, also described by Pasley (but not made by him), were made with the lengths of the brick vertical, and gave the following results:—Twenty-two

* Pasley on *Cements*.

bricks were stuck out, one after another, with neat cement, the intervals between the setting of the bricks being only five or six minutes, and on adding the twenty-third brick the mass fell. As many as *thirty bricks* were stuck out in the same way *in one day*.

Similar cement to that used in the first-mentioned experiment was tested for adhesion by cementing *five* bricks together, and then pulling them asunder, when from 955 lbs. to 1,875 lbs. were required to separate the brickwork at the joints. The bricks would have a superficial area of, say, 40 square inches on their cemented faces, so that the adhesive strength was from about 24 lbs. to 47 lbs. per square inch. The maximum calculated tensile or adhesive stress, *f*, in the brick-in-cement cantilever

Tests of the same cement for adhesion under *direct* pull gave the following results :—

At 40 days old, 66 lbs. per square inch failed to separate the joints.

At 65 days old, 80 lbs. per square inch also failed to separate the joints.

But this gives no proper idea of the real adhesion, as a weaker cement at seventy-four days bore 4,455 lbs., or nearly two tons on the surface of a brick without failure. This gives not less than 110 lbs. per square inch adhesive strength of the weaker cement at seventy-four days old. The sketches of the brick cantilevers are to scale, so as to give a better idea of the experiments. The apparatus

PASLEY'S EXPERIMENTS ON BRICK CANTILEVERS.

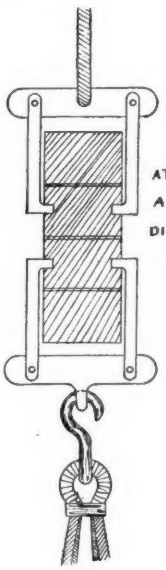


FIG. 3.

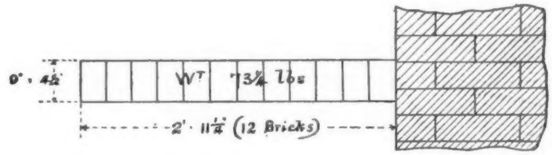
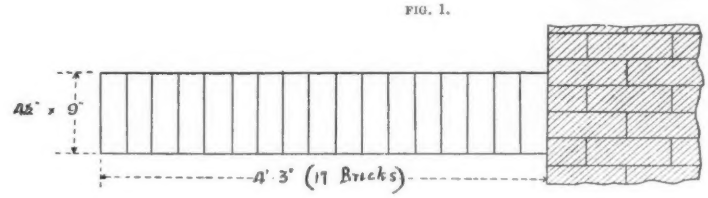


FIG. 1.



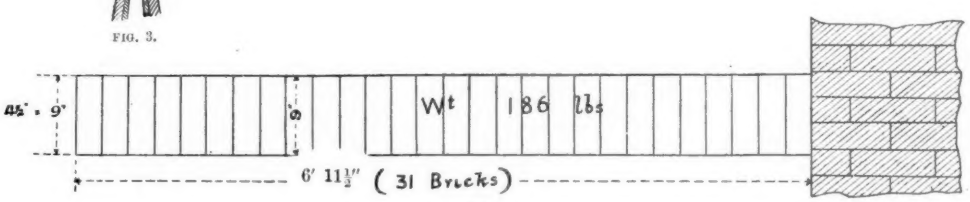


FIG. 2.

tested by Pasley amounted to about 42 lbs. per square inch, which agrees well with the higher result of the test for direct adhesion; but unfortunately the age of the mortar in the tests for direct adhesion is not given by Pasley.

General Pasley subsequently, in 1836, improved his cement and repeated his experiments, with the result that he succeeded in adding one brick after another at the rate of one every day (except Sundays) until thirty-one bricks stood out horizontally from the wall, with a length of 6 feet 11½ inches, and weighing 186 lbs. (fig. 2). The bricks in this case had their length vertical. Assuming these bricks to be similar to those used in Pasley's earlier tests, say 9 in. × 4½ in., the calculated maximum tensile or adhesive stress, *f*, would be about 128 lbs. per square inch, the mortar at the inner end of the cantilever being thirty-five days old when failure occurred.

and mode of testing the adhesive strength direct is also shown by a sketch (fig. 3).

It should be noted that the cement made and used by Pasley was composed of the same materials—chalk and clay—as Portland cement, but in different proportions, and it was probably much quicker setting than the Portland cement now in common use.

The late Mr. John Grant stated that he had found that the adhesive strength of mortar of 1 part Portland cement to 2 of sand amounted to from 15 lbs. to 30 lbs. per square inch at twenty-eight days old, variations in the nature of the bricks having great influence on the adhesion. I have made these references to the *direct* adhesive strength because it is a direct measure of the transverse strength of the brick cantilevers as tested.

Turning now to *brickwork* in *lime mortar*. Experi-

ments on brickwork beams of large size were made at Narora, in India, by Lieut. E. W. Cresswell, R.E., some years ago, and described in the Roorkee Engineering Papers. The experimental beams were fifty in number, built in English bond in mortar made of two parts of Kankar lime to one part of sand. The dimensions of the beams and mode of loading are shown on the sketch, which is to scale (fig. 4). The beams were 15 feet long by 2 feet 6 inches square, with clear spans of 10 feet. The bricks were all carefully selected, so that the dimensions of all the beams were identical. Ten beams were tested with each of five different thicknesses of mortar joints, $\frac{1}{16}$ inch, $\frac{1}{8}$ inch, $\frac{1}{4}$ inch, $\frac{1}{2}$ inch, and $\frac{3}{4}$ inch respectively. The Kankar lime was partly made from nodules found in the soil and partly from quarried block Kankar limestone. The average *tensile* strength of briquettes of mortar composed of 1 of Kankar lime to $1\frac{1}{2}$ of sand, as tested by Major Twemlow, R.E., at the Krishna Bridge, was 50 lbs. per square inch at one month old, increasing to 65 lbs. at two months old, and determine the best thickness of mortar joints, and this alone is sufficient to make the experiments of great value. The beams must have been very well made (in all probability by native bricklayers), as the tests showed remarkable uniformity in strength for each set of a given thickness of joint.

The average load of rails placed upon each set of ten beams was as follows:—

For joint	$\frac{1}{16}$ in.	$\frac{1}{8}$ in.	$\frac{1}{4}$ in.	$\frac{1}{2}$ in.	$\frac{3}{4}$ in.
	6·92 tons	7·79 tons	8·12 tons	5·22 tons	4·92 tons

These loads are rails alone, and the weight of the clear span (10 feet) of the beam itself amounted to 3·42 tons. The beams with joints $\frac{1}{4}$ inch thick gave the greatest average strength, and also the greatest uniformity in strength. In every case the line of rupture of the beam occurred between the stone bearers, and was generally as shown on the drawing.

Calculating the maximum tensile or compressive stress

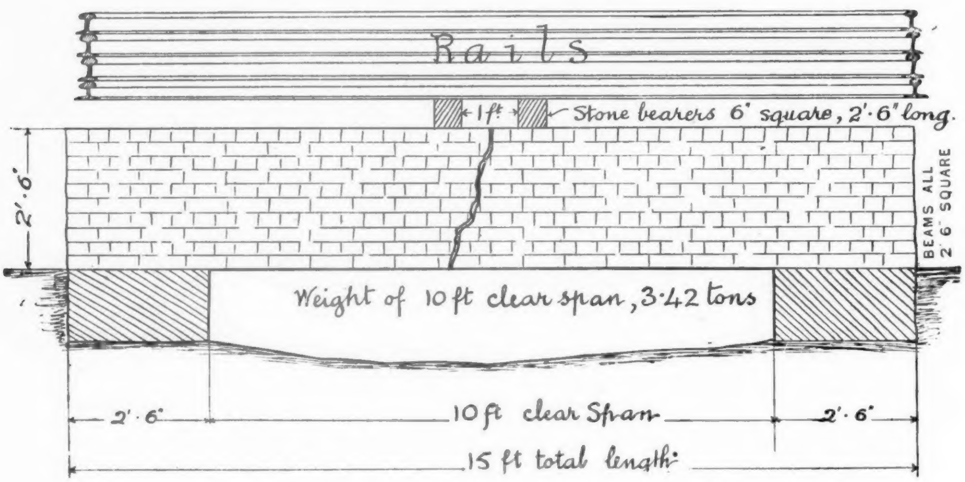


FIG. 4.—TESTS OF BRICKWORK BEAMS WITH VARIOUS THICKNESSES OF JOINTS.

Brickwork in English bond. Mortar:—Kankar lime, 2 parts; sand, 1 part. Beams, 9 to 11 months old when tested.

Average loads of rails which broke beams.

Thicknesses of Joints	$\frac{1}{16}$ in.	$\frac{1}{8}$ in.	$\frac{1}{4}$ in.	$\frac{1}{2}$ in.	$\frac{3}{4}$ in.	
=	6·92 tons	7·79 tons	8·12 tons	5·22 tons	4·92 tons	not including the weight of beam itself.

Values of "f," or modulus of rupture, including effect of beam's weight.

All based on clear span being assumed as the effective span							
	Maximum	133 lbs.	152 lbs.	143 lbs.	115 lbs.	100 lbs.	per square inch.
	Minimum	96 "	101 "	112 "	72 "	72 "	" " "
	Average	114 "	124 "	129 "	92 "	88 "	" " "

continuing to increase up to one year old. This gives us an idea of the character of the Kankar lime mortar so far as *tenacity* is concerned, and from such data as I have been able to find it appears to have been somewhat similar in tensile strength to our hydraulic lime mortar.

In making the beams tested at Narora, a bedding of brickwork laid, I believe, in mud or dry sand was laid over the clear span, and this bedding and the bearings at the ends formed a level plane upon which the beams were built. This bedding was removed before loading the beams, which were made in August 1877, and tested in May and June 1878, so that they were from nine to eleven months old. The load imposed on the beams consisted of rails resting upon two stone bearers 6 inches square and 1 foot clear apart, equidistant from the centre of the span. The rails were piled up successively until the beams broke. One of the primary objects in testing these beams was to at the bottom and top of the beams we find that, taking the clear span as being the effective span, and including the effect of the beams' own weight, the stresses for the different thicknesses of joints were as follows:—

		$\frac{1}{16}$ in.	$\frac{1}{8}$ in.	$\frac{1}{4}$ in.	$\frac{1}{2}$ in.	$\frac{3}{4}$ in.	
f max.	=	133	152	143	115	100	lbs. per square inch
f min.	=	96	101	112	72	72	" " " "
f, aver. of ten tests	=	114	124	129	92	88	" " " "

As it is difficult to follow a statement of results without seeing them in figures, I have tabulated the results under the sketch of the beam (fig. 4). The uniformity is very surprising when we reflect that the material was nothing but bricks and mortar. In these Indian experiments there can be no doubt but that the bond had a great influence in producing the high results obtained, and in this case the

adhesive strength measured by direct pull would not give us a direct measure of the transverse strength since the bonding interlocks the courses together, whilst in Pasley's tests with brick in cement the bricks were simply stuck to each other and to the wall.

My object in thus directing your attention to the transverse strength of brick beams is not with any idea of inducing anyone to substitute bricks and mortar for steel or iron or timber girders, but only with a view to point out that brickwork has a definite amount of transverse strength upon which we can, with the exercise of proper discretion, to some extent rely. To show the practical value of considering this subject, it is only necessary to ask the questions: (1) Upon what principles should we determine the thickness and proportions of brick footings to walls and columns? (2) What load is imposed by a mass of brickwork on a girder spanning an opening in a wall? (3) Is it safe to cut a large hole in a wall without going to considerable expense in inserting needles and heavy underpinning supports before making the hole?

A little consideration shows that the common footing to a wall or column is greatly dependent on transverse strength in its duty of spreading the superincumbent load over the foundation earth, the more or less concentrated load being opposed by a distributed resistance under the whole width of the footing.

Using the ordinary theory for the strength of beams, and noting that the projecting parts of the footings are simply cantilevers with the distributed load acting upwards, we have $\frac{wl^2}{2} = \frac{fbd^2}{6}$, f here being the maximum safe stress per square inch, tension or compression, whichever gives the smaller value, the tensile stress here being the governing factor.

Since f is in lbs. per square inch, the other factors in the equation should be also in inches, and w should be taken in lbs. per square inch.

From this equation, by transposition, we obtain the result that

$$\frac{bd^2}{l^2} = \frac{3w}{f},$$

and when b = unity,

$$\frac{d}{l} = \sqrt{\frac{3w}{f}}.$$

That is to say, the ratio of the depth to the projection of a footing varies as the square root of the pressure per unit of foundation area, and it also varies inversely as the square root of the allowable stress per square inch, in tension, on the material.

Taking a practical illustration of this, let us assume that the ground is of such a nature that one ton per square foot is a proper load to allow, and let our footing project 1 foot and have a thickness of 1 foot 6 inches; then if we have in another part of the work a much harder ground, which can carry four tons per square foot, if the footings still require to have a projection of 1 foot, the increase in the load per square foot requires us to make the footing twice the former thickness, or 3 feet thick in place of 1 foot 6 inches. Briefly, with any given projection of footing, we must make the thickness to carry four tons per square foot twice the thickness for one ton per square foot.

In applying the principles of the strength of beams to footings, the unknown factor is the safe allowable tension on the brickwork, and the experiments on large brick beams previously described give us some idea of what we may expect from materials similar to those from which the beams were made.

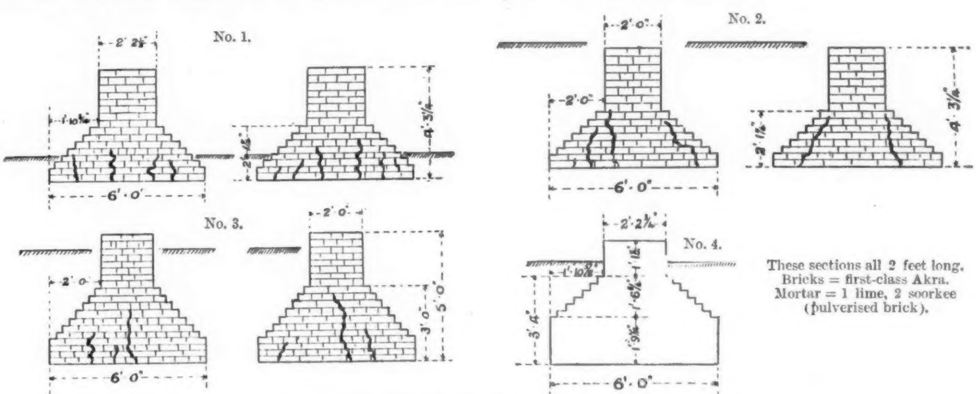


FIG. 5.—MR. HUGH LEONARD'S EXPERIMENTS ON FULL-SIZE FOOTINGS.

No. 1, 19 days old, cracked at 1·018 ton per square foot. f = 38 lbs. per square inch.
No. 2, 3 months 2 days old, cracked at 1½ ton per square foot. f = 63½ lbs. per square inch.
No. 3, 15 days old, cracked at 1¾ ton per square foot. f = 36 lbs. per square inch.
No. 4, 3 months old, did not crack at 2 tons per square foot. f = 29½ lbs. per square inch without causing failure.

NOTE.—The two sketches under Nos. 1, 2, and 3 show opposite sides of the same footing in each case.

The values of f, the ultimate tensile strength, obtained from these experiments only require to be divided by a suitable factor of safety to give us the working stress, f, in the formula just given for the ratio of thickness to projection of footing.

These values of safe stress would of course only apply to brickwork of the same class and of the same age as the experimental beams, and perhaps the best mode of obtaining the proper value for f would be to make direct experiments on full-size footings, and some very valuable tests* were made in 1873 by Mr. Hugh Leonard [*H.A.*], in Bengal, which I will describe. The footings as constructed are shown on the drawing (fig. 5), together with the load per square foot at which they failed, or, rather, at which cracks were developed. The age of the brickwork at the time of the tests, the position of the cracks, and the values of f, the ultimate calculated stress, are also shown. The bricks were described as first-class Akra bricks, and the mortar was composed of one part of lime to two of soorkee. Soorkee is pulverised brick.

* *Engineering*, vol. xx. p. 103.

The ratio of the depth to the projection in the first experiment was 1·11, so that as the footing failed when the load on the ground was 1·018 ton per square foot, or nearly 16 lbs. per square inch, the calculated maximum tension, *f*, would be nearly 38 lbs. per square inch, the masonry being nineteen days old. In the second footing the brickwork cracked when the load was $1\frac{1}{2}$ ton per square foot on the ground, or $23\frac{1}{4}$ lbs. per square inch, and the ratio of depth to projection being 1·05, *f* works out to $63\frac{1}{2}$ lbs. per square inch, the masonry being three months two days old. Comparing these results we see the increase in strength due to the greater age of the second footing. In the third experiment the ratio of depth to projection was 1·5, and cracks were developed when the load on the ground was $1\frac{3}{4}$ ton per square foot, or nearly $27\frac{1}{4}$ lbs. per square inch, and *f* works out to about 36 lbs. per square inch maximum calculated tension, the masonry being fifteen days old. Comparing this with the first test, the increase in the strength of the footing due to increased depth is evident. The deeper footing, although having four days less age, carried nearly 72 per cent. more load per square foot, with very nearly the same maximum tensile stress per square inch. In the fourth experiment the ratio of depth to projection was 1·78 nearly, and a load on the ground of 2 tons per square foot or a little over 31 lbs. per square inch failed to crack the brickwork. This load would produce a maximum calculated tension of $29\frac{1}{2}$ lbs. per square inch nearly, the brickwork being three months old.

These experimental footings all rested upon soft alluvial soil, at the depths shown on the drawings; and from the results of the tests of the brickwork at fifteen days old and nineteen days old, which gave ultimate calculated tensile stresses of 36 lbs. and 38 lbs. per square inch respectively, I think we may safely use 18 lbs. as the *safe* stress per square inch, or working value of *f*, in ordinary brickwork footings, as the strength of the mortar keeps on increasing with an equivalent increase in the margin of safety, as evidenced by the much higher value of $63\frac{1}{2}$ lbs. per square inch maximum ultimate stress in the second experiment, and the calculated stress of $29\frac{1}{2}$ lbs. per square inch without failure in the fourth test, where the brickwork was in each case about three months old. There was no concrete bedding under these footings, as the object was to test the brickwork only. It will be noticed that, when the extreme toes of the footings were thin, cracks occurred immediately at the toes, pointing to the necessity for keeping them somewhat thicker than was the case in these particular experiments, in order to ensure that the extreme bricks are properly bonded into the body of the footing.

Attention may also be directed to the mode of failure generally, the main cracks occurring in the centre of the base or thereabouts. A failure of this nature under ordinary circumstances might easily escape notice, and lead to the false conclusion that the movement of the wall was caused by insufficient width of footing causing too great a load per square foot on the ground.

The estimation of the strength of footings in the manner indicated errs somewhat on the safe side, as the surrounding earth, if well rammed down at the sides, will tend to prevent any spreading by providing an abutting surface for the vertical face of the toe; but the calculation can necessarily take no notice of this, as its value is quite indeterminate. Again, the bond of the brickwork brings into play, in the case of a footing, a very considerable amount of friction between the surfaces of the bricks, and it is quite conceivable that even if no mortar were used at all in the lower courses, the calculation of transverse strength would assign a very appreciable value to *f*, the apparent tensile stress, and it was for these reasons that I suggested the advisability of referring to direct tests of footings themselves rather than to tests of simple beams uninfluenced by such conditions.

The friction between the bricks has the effect of assigning a higher value to the tensile strength of brickwork than would be obtained from simple beams of the same materials, and the value of *f*, as deduced from the tests of footings, is really a compound of tensile strength and frictional resistance.

Before leaving this subject of footings, brief reference may be made to a type of column foundations in common use in Chicago, that city of lofty buildings, sixteen, eighteen,

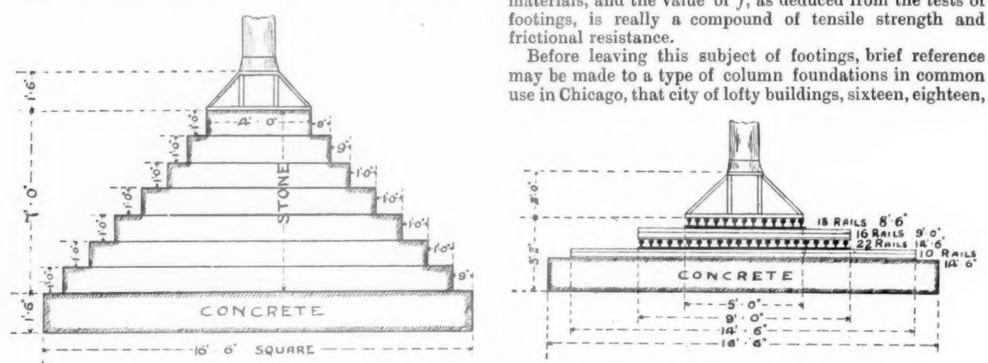


FIG. 6.—TYPE OF COLUMN FOUNDATIONS IN ORDINARY USE IN CHICAGO.

and even twenty storeys being not uncommon. The soil on which Chicago is built is of a very yielding and treacherous nature, which has led the architects and engineers of that city to devote great attention to the subject of foundations. The construction of these foundations for columns is shown on the drawing (fig. 6), and hardly needs description.

The foundation consists of a bed of concrete upon which are laid several courses of steel rails, laid alternately across each other and surmounted by the column base. The advantages of this type of foundation, as compared with a foundation of solid masonry, are: (1) A very considerable reduction in the weight of the foundation itself; (2) much less depth of excavation, or, if the depth be the same, much less space occupied in the cellarage. In a particular instance the difference in weight might easily be such as to allow of an extra storey being added to the building without increasing the weight on the ground. For comparison, a masonry base is also shown on the drawing.

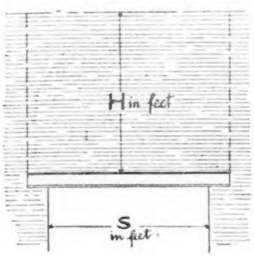
Turning now to the question as to what load is imposed by a wall on a girder spanning an opening in the wall, from the experiments which I have described it will be at once seen that the brickwork itself may act as a beam, and, since the weight of the wall increases only in proportion to the weight above the girder, whilst the transverse strength of the brickwork increases as the square of the height, there is then a certain depth of wall which will be entirely self-

supporting, a very short time after the brickwork is laid, and the transverse strength of the brickwork might easily be such as to require little or no assistance from a girder.

Referring to the tests of the large brickwork beams in India, it will be remembered that they were not only self-supporting, but required the addition of very heavy central loads to break them without any assistance from a girder, or other support, after they were a few months old. It can be shown (by very simple calculations, involving only the weight of the brickwork and its transverse strength) that, assuming brickwork to weigh 120 lbs. per cubic foot, the height of the wall, which will be just self-supporting, is

$$H = \frac{5s^2}{8f},$$

H being the height of the wall in feet above the opening, s being the clear span or opening, also in feet, and f being the tensile strength per square inch (fig. 7).



$H = \frac{5s^2}{8f}$.

FIG. 7.

H = height of wall in feet.
s = clear span in feet.
f = modulus of rupture in lbs. per square inch.

It is quite immaterial how much higher we raise the wall after we reach this self-supporting height; any greater height only makes the brick beam stronger and stiffer, and reduces the load on the beam or lintel underneath. Assuming the clear span or opening to be 12 feet, and the tensile strength of the brickwork to be only 5 lbs. per square inch, then a height of 18 feet of brickwork would be self-supporting over the 12 feet opening.

If the opening occurred in a considerable length of wall, the brick beam would be somewhat stronger from the partial fixity of its ends, which has not been taken into account in the formula already given. Girders of timber, iron, or steel are, of course, none the less essential under the brickwork, since a very slight settlement of foundations might cause cracks in the brickwork beam; but my object is to point out that the supposition of a distributed load of brickwork devoid of cohesion or transverse strength is, to say the least, a very safe one.

Looking at this subject in this light, it would appear to be a wise practice to build the first few feet of brickwork on girders spanning openings, in cement mortar, to ensure having considerable tensile strength in the lower part or tension side of the brickwork beam. The actual load carried by a girder spanning an opening under a wall is also dependent upon the speed with which the brickwork is carried up, and upon the relative stiffness of the masonry beam and the timber or steel or iron girder.

Timber Beams and Framed Floors.—The next subject to which I shall direct your attention is the actual strength of timber beams and framed floors.

The estimated strength of wooden beams is frequently based on the results of numerous experiments made on specimens of small size, and of carefully selected and seasoned timber, with the result that a very erroneous estimate is formed of the strength of timber of the usual working dimensions. As a matter of fact, large-size timber has only from one-half to three-fourths of the strength of small timber, as measured by their coefficients of transverse strength given in the great majority of text-books, by various authorities, on the strength of materials.

The same discrepancy exists between large and small specimens tested for direct compression, column strength, and resistance to shearing. It should also be mentioned that the *comparative* strength of small specimens of different timbers is not the same as the comparative strength of large specimens.

A few comparisons of transverse strength may be given to illustrate this. Taking Baltic fir timbers, Riga Memel and Dantzic, fifteen tests, extracted from various records, on small-size test pieces from 1 in. × 1 in. to 3 in. × 3 in., gave an average coefficient of transverse strength, K = 1,587 lbs., the maximum being 2,013 lbs. and the minimum 1,148 lbs. Eleven tests of large-size timbers of Baltic fir, principally Memel, ranging from 9 in. × 3 in. to $13\frac{1}{2}$ in. × $13\frac{1}{2}$ in., gave an average value of K = 761 lbs., the maximum being 1,000 lbs. and the minimum 533 lbs. The large timbers thus had somewhat less than half the strength of the small specimens.

With red pine similar results are found. Nine tests of small-size pieces not larger than 3 in. × 3 in., mostly American red pine, gave an average coefficient K = 1,423 lbs., with 1,680 lbs. maximum and 1,169 lbs. minimum. Five tests of large-size red pine from 6 in. × 6 in. to 12 in. × 12 in. gave 793 lbs. average value of K, with 873 lbs. maximum and 714 lbs. minimum. The large-size red pine had on an average only 55 per cent. of the strength of the small test pieces.

Pitch pine is credited with an average coefficient K = about 1,700 lbs., but nine experiments on large beams from 12 in. × 6 in. to 14 in. × 15 in. gave an average of 1,245 lbs., the maximum being 1,400 lbs. and the minimum 972 lbs., as the value of the coefficient K. These large pitch pine beams had only 73 per cent. of the strength of the small specimens, on an average. The same difference occurs with other timbers, and the use of these coefficients based on small specimens should be entirely discontinued.

Table showing Comparative Strength of Timber, in Small and Large Scantlings, when tested for transverse strength.

	Small	Large	Per cent. Ratio $\frac{\text{Large}}{\text{Small}}$
Baltic fir .	1,587 lbs. average	761 lbs.	48 per cent.
Red pine .	1,423 " "	793 "	55 "
Pitch pine	1,700 " "	1,245 "	73 "

Note.—These values represent "K" in the formula

$$W = \frac{4Kbd^2}{l} \text{ for central load.}$$

Professor Lanza, of the Massachusetts Institute of Technology, has made a large number of tests of large-size timbers of American growth, such as yellow pine, spruce fir, white fir, white oak, and hemlock, which also add their testimony to the inaccuracy caused by relying on tests of small-size pieces. One of the most striking results of Professor Lanza's experiments is that he found that almost as often as not a timber beam will fail by longitudinal shearing, in preference to tearing or crushing, in the manner usually associated with failure under transverse bending. This really means that the shearing strength parallel to the fibres must be carefully kept in mind, and for any particular beam of a given cross-section there is a certain span at which the ultimate load becomes a maximum, and no shortening of the span will enable us to impose any greater load, as the beam at the span of maximum strength becomes dependent on the shearing strength, and not on the tenacity or compressive strength of its fibres (fig. 8).

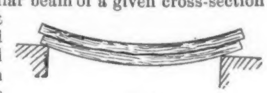


FIG. 8.

Failure by longitudinal shear in timber beam.

In the construction of wooden framed floors, the common practice of notching, mortising, and tenoning has a most important influence upon the strength of the work, and to determine this, Professor Lanza made a number of experi-

ments upon portions of full-size framed floors.* These portions of framed floors were of the type shown in the drawing (fig. 9). The wood used was (in one set of tests) American yellow pine, and the joists were framed into the headers by tusk and tenon joints, and the headers were in some instances framed into the blocks at the corners by double tenons and joint bolts, and in other instances the ends of

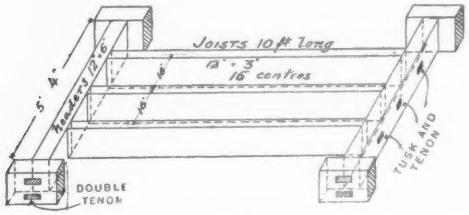


FIG. 9.

Joists covered with 1 inch yellow pine flooring. Test loads applied at centre of joists, and divided equally among the three by iron bridging.

the headers were hung from the corner-blocks by stirrup-irons.

I have calculated the apparent coefficients of transverse strength of the headers thus weakened by the tusk and tenon mortises, and find that they varied from 151 lbs. to 187 lbs., the *average of five tests being nearly 156 lbs.* for the value of the coefficient K; whereas a 12 in. × 6 in. yellow pine beam of the same span, but uninjured by mortises, had an apparent coefficient of transverse strength of nearly 890 lbs., and this was considerably below the average of a large number of other tests of yellow pine beams. Comparing the mortised headers with this 12 in. × 6 in. beam of much less than average strength, we see that the effect of the mortises was to reduce the strength to only 17 per cent. to 20 per cent. of what we might have relied on in the uninjured beams. The average strength of the headers was only $17\frac{1}{2}$ per cent. of the uncut beam, or the uninjured beam was nearly $5\frac{3}{4}$ times as strong as the mortised headers. Nine similar tests of spruce headers, 12 in. × 4 in. and 12 in. × $3\frac{3}{4}$ in., under similar conditions, showed that the strength was only from 20 per cent. to 25 per cent. of the strength of uninjured beams. In some of these tests the joists also showed signs of weakness by splitting under the tusk close up to the headers.

I have called the calculated coefficient of transverse strength in these tests an "apparent" coefficient, because in most of these headers failure was caused by longitudinal shearing at the middle of the depth, just where the mortises were cut into the beams, and the strength was dependent on shearing, and not upon the tenacity or compressive strength of the fibres. It should especially be noticed that the comparison instituted between the mortised headers and the uncut beam is a comparison between beams of usual practical dimensions, and the uncut beam was below the average strength, as measured by the coefficient of transverse strength.

The results of these tests are sufficiently striking, and merit the attention of everyone engaged in the design or construction of timber work.

Steel and Iron Joists.—The use of steel and iron rolled and built girders and joists is now so universal that no excuse is needed for a consideration of some theoretical and practical points in connection with them. The rolled joists of mild steel now in the market are very greatly superior to what can be obtained in iron; and comparing the two materials, steel and iron, strength for cost, steel comes out far ahead of iron, to say nothing of its greater ductility and reliability, especially when in the form of joists, a section for which steel is more suitable than iron, owing to difficulties in rolling the latter.

As far as corrosion is concerned no doubt iron has some advantage in being less vulnerable; but seeing that steel joists can be bought for the same price as iron, and have about one-third greater strength, there can be but little reason for adopting the older material. It should also be borne in mind that a steel joist has a very much greater ultimate deflection than an iron one of similar section, so that where a steel joist would bend down, and probably give some warning of its weakness, an iron joist would probably snap short (that is, as compared with the steel joist).

The cheaper kinds of foreign rolled joists should be studiously avoided; at the same time, if similar prices be paid, there is no doubt that thoroughly reliable joists can be got from abroad. It is very desirable that no holes be made in the tension flanges of rolled joists. The existence of a single hole in the tension flange, near the centre of span, would immediately reduce the ultimate deflection, and failure would be almost certain to take place at the hole.

In looking over makers' and merchants' tables of safe loads, it is usually found that the most important items of information are omitted, *i.e.*, the factor of safety and the ultimate tensile or compressive strength of the material. If these tables of safe loads were to come into general use, there would be great inducement for makers and merchants to base their estimates of safe loads upon dangerously low factors of safety, with the object of making their joists appear so much stronger than those of their competitors. No true idea of the safe load on any joist or girder can be obtained without careful consideration of the circumstances of each case as it arises, together with a comparison of the maximum fibre stress with the ultimate strength of the material used. The makers' tables of safe loads are, as a rule, based on the tensile strength of the material only, ignoring altogether the fact that the compressive strength both of steel and iron is much less than its tensile strength. In addition to this, it is absolutely necessary to consider the *column* strength of the compression flange when it is not held rigidly in line at short intervals and prevented from yielding laterally.

The stress allowed should be made subject to the ratio of the width of flange to its unsupported length, and in some measure, also, in proportion to the depth of the girder, where the depth is great in proportion to the flange width.

To show how important it is that these tables of safe loads should be used with the utmost caution, two experiments made at Glengarnock Works in 1893 may be described.

Two tests of mild basic steel joists were made, each joist having a clear span of 15 feet, with a distributed load. The first joist was 12 in. × 6 in. × 54 lbs., and failure was caused by a load of 50 tons. On referring to the tables of one of the largest makers of steel joists, we find the safe load on a similar joist stated as slightly over 30 tons.

The second joist was 10 in. × 6 in. × 42 lbs., and failure was reached at $34\frac{1}{2}$ tons. Again, referring to the same table of safe loads, and making allowances for a slight difference in weight between the joist tested and that in the tables, the safe load should be nearly $18\frac{1}{2}$ tons, according to the particular maker's table referred to.

If the tabular safe loads mentioned were actually to be imposed in practice, we should have a factor of safety of about $1\frac{2}{3}$ in the first instance, and about $1\frac{7}{8}$ in the second. The calculated stress, in each case, in the flanges at the time of failure was 21 tons per square inch tension or compression, and failure was in each case caused by the top flange bending out sideways (exactly as a column would do) under compressive stress. The tensile strength of the steel used in the joists was stated to be 27·7 tons per square inch in the 10-inch joist, and 29·6 tons per square inch in the 12-inch joist.

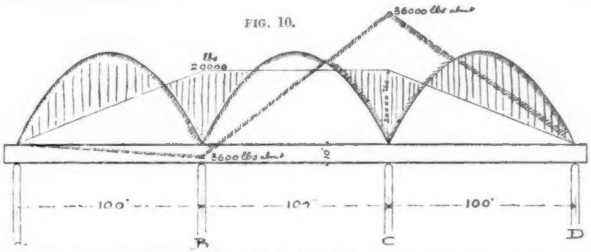
We also frequently find, in these makers' and merchants'

* See Professor Lanza's *Applied Mechanics*.

tables, statements as to the strength of fixed ended beams. The strength of fixed ended and continuous beams is also constantly referred to in text-books on structural design, and formulæ professing to give their strength are often given very fully without any mention being made of the conditions to be met if we are to obtain the additional strength due to continuity or fixity of ends. In ordinary practical work such a thing as a perfectly fixed ended beam or a perfectly continuous girder rarely exists, and the conditions essential to them are so difficult of attainment that continuity and fixity of ends should be entirely left out of account in estimating the strength of the beams, although there are frequently other practical advantages in making beams or joists continuous.

One of the first conditions necessary to obtaining any advantage in strength from continuity is the absolute rigidity and invariability of level of the supports. Let us assume a typical case—say three spans of continuous mild steel girder of uniform section from end to end, each span being 100 inches, and the depth of girder being 10 inches. Let the maximum safe stress per square inch be fixed at 20,000 lbs. (the girder being assumed to be properly supported to prevent lateral failure). Assume the supports to be dead level and the girder to be originally perfectly straight, then the diagram (fig. 10) shows the stresses in the different portions of the girder, by the areas hatched with vertical lines.

FIG. 10.



ERRATUM.—In this figure vertical hatching should have been shown between the curve and above the upper horizontal line immediately over the middle of the central span.

The continuity causes the maximum stress of 20,000 lbs. to be immediately over the piers. If there were no continuity the stress from the same load on the same girder would have been 25,000 lbs. per square inch at the centre of the spans.

If now the pier B should settle less than half an inch, or, say, four-ninths of an inch, or should be that much out of level to start with, the whole state of things is changed, and the stresses are enormously increased.

The span A B is in worse condition than it would have been had no continuity existed, and the stress over the pier C rises to about 36,000 lbs. per square inch, or 80 % more than the maximum safe stress originally decided upon as the limit. The diagram indicates these new stresses by the hatching of diagonal edging lines. The vertical depth of the area included by this diagonal hatching gives the stress at any point.

The same state of things would be caused by the pier B being, say, two-ninths of an inch too low to start with, and settling two-ninths of an inch in its foundations afterwards.

A much less settlement would suffice to raise the maximum stress considerably above the original expectations.

Such delicacy of adjustment or such unyielding foundations can, I think, scarcely be looked for in ordinary building operations. The assumption of beams as being fixed ended is also open to practical objection.

Again taking a typical example, assume the span as 12 feet and the depth as 12 inches, and let the beam be 17 feet long over all, the ends overhanging the points of support by 2 feet 6 inches at each end, as shown in the drawing (fig. 11). Then, if the load on the clear span of 12 feet be 25 tons (which would be a quite suitable dead load if the fixity of ends were fully realised, the beam being, say, 12 in. × 5 in. × 39 lbs. per foot), we should have to impose

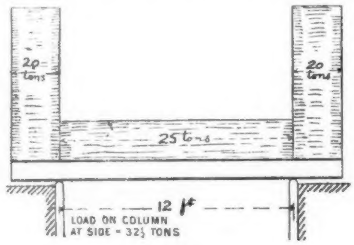


FIG. 11.

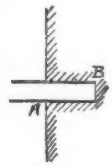


FIG. 12.

20 tons on each of the overhanging ends in order to fully obtain the fixity of these ends; and, more than that, we would have to give these *fixed* ends free scope to deflect downwards under their load of 20 tons each.

These are the conditions under which the formulæ for fixed ends are calculated, and we only need to look at the sketch of a beam end built into a wall (fig. 12) to see how far we are from realising these conditions.

The drawing of the beam, showing the theoretic fixed ends, also shows, to scale, the proportionate loads on the 12-foot span and the 2 feet 6 inches long ends. It is not probable that in ordinary circumstances the load on the clear span will be $2\frac{1}{12}$ tons per lineal foot while the load on the *fixed* ends is 8 tons per lineal foot, and it is equally unlikely that the provision of a free space under the ends will be made in practice to allow the ends to deflect downwards. The truth is, that in practice the ends of girders are not fixed in the manner assumed in the theory of fixed ended beams, and a very minute settlement of the side supports or shrinkage of the masonry surrounding the ends of the girder would immediately destroy any partial fixity that may have existed when the work was new.

Columns.—The next subject in my Paper is that of "Columns," considered more particularly with regard to the influence of eccentric loads or loads imposed on the sides of columns. The ordinary column formulæ such as Gordon's or Rankine's, giving the ultimate crippling strength per square inch for columns of different lengths and diameters, do not directly give any idea of the internal state of stress existing in a column.

In some of the older authorities on the strength of materials the statement is made that when a column is less than a certain number of diameters long it fails by crushing, and when it exceeds this length it fails by bending. We now have much better knowledge of this subject, and we know very well that no such sudden change exists practically, although the statements are perfectly correct for materials of perfectly uniform elasticity. The failure of all columns of the materials at our command is due more or less to eccentricity, not of loading, but of resistance, some parts of the columns yielding, in an elastic sense, more than others, and thus causing the centre of elastic resistance to differ from the centre of figure or axis of the columns. This causes flexure under even the smallest loads, and on continuing to increase the loads the column ultimately fails by insufficiency of tensile or compressive strength. A fuller consideration of this subject would be out of place here, as my object is to draw atten-

tion not to eccentricity of resistance but to eccentricity of loading as referred to the axis of the column. Again taking a typical case, let us consider the effects of a side load on a short hollow column such as is shown in fig. 13. Let the sectional area be 20 square inches, and the thickness of the column one-tenth of the diameter.

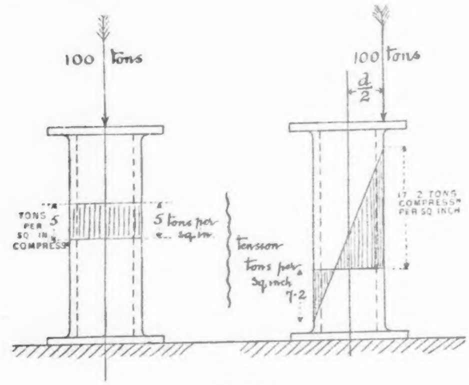


FIG. 13.

Thickness of column = $\frac{1}{10}$th diameter.
Sectional area of column = 20 square inches.

If the load be 100 tons, the average apparent stress will be 5 tons per square inch with the load central.

If now the load be moved from the centre to the extreme edge of the column, the maximum stress immediately rises to 17·2 tons per square inch compression, and the load produces a tensile stress of 7·2 tons per square inch on the other side. A deviation of the load from the centre, if only ·205, or a little over a fifth of the diameter, is sufficient to double the stress, or raise it to 10 tons per square inch in this short column, and in a long column the effect would be much more serious. If loads must be carried on the sides of columns, very careful and full allowance should be made for their effect. The load on a column may (quite unintentionally) be eccentric. This may easily be caused by the deflection of a girder resting on the column head, causing it to bear right on the edge, as indicated in fig. 14.

In order to avoid this, and to ensure that the load should be as far as possible central, columns have been

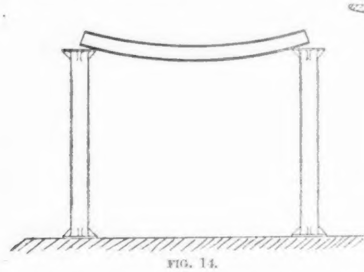


FIG. 14.

FIG. 15.

made with rounded ends, having a cup fitted upon them allowing of a slight amount of rotation (fig. 15). This device was entirely hidden from view by ornamental capitals and bases. Wherever possible, capitals should be purely ornamental, and should have nothing to do with the actual support of the load.

It will be apparent from the preceding remarks that a large flat capital cast solid with the column may be a very great disadvantage.

It may not be out of place here to mention that the influence of eccentric loading has a great influence upon foundations and joints in masonry. The diagram (fig. 16) shows, for rectangular bases under vertical loads, the effect of the deviation of the resultant load from the centre of the base. The horizontal line at the foot of the diagram represents half the base width. The vertical distance from the base line to the horizontal line immediately above it represents the

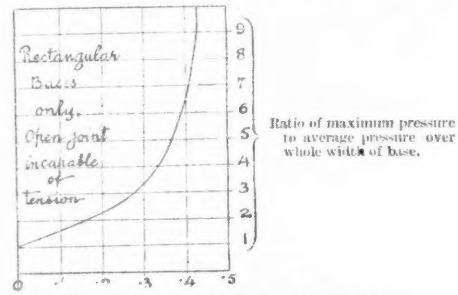


FIG. 16.—Diagram showing increased maximum intensity of pressure on foundation or joint, due to deviation of resultant from centre of base.

uniform pressure per square foot over the whole width of base when the resultant is central. When the resultant passes through any other point than the centre, the vertical ordinate from the base to the *curve*, measured to the same scale as the average load per square foot, gives the maximum intensity per square foot at the edge of the base nearest to the resultant. Assuming the uniform pressure to be 1 ton per square foot when the load is central, then, when the load deviates from the centre to a distance of only one-sixth of the width of base, the load per square foot is doubled, or rises to 2 tons per square foot maximum. The maximum pressure increases very quickly with the deviation, and when the deviation reaches to one-third of the base width, the maximum pressure is four times the average uniform load caused by central loading.

An unsymmetrical base may thus have much too great a maximum pressure per square foot, and, under certain circumstances, might be much reduced in width, and still afford greater safety. For instance (fig. 17), a base, 9 feet wide, loaded with 10 tons, acting 1 foot 6 inches out of centre, would have a maximum pressure per square foot of $2\frac{2}{3}$ tons, but if the width were reduced to 6 feet by cutting off 3 feet from the greater side the load would be central, and the maximum intensity would only be $1\frac{2}{3}$ ton per square foot, although the base is one-third less in width.

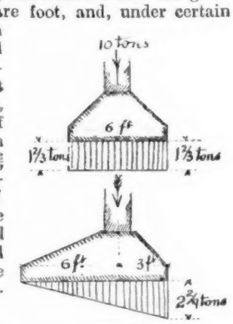
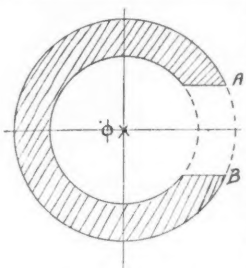


FIG. 17.

In the case of a tall chimney now being built to my firm's designs at Elswick, a large flue-hole is to be left in one side at the very base, and, as the hole is somewhat larger than usual, I thought it desirable to calculate what would be the effect in the maximum pressure per square foot on the brickwork. The chimney is 110 feet high, and weighs 337 tons, and the flue-hole has the effect of shifting the centre of resistance to a distance of 1 foot from the

centre of the main body of the chimney (fig. 18). It was found that this would cause the maximum compressive stress at the points A and B to be 7·65 tons per square foot, from the permanent load of the chimney alone, while a moderate amount of wind pressure would raise the stress to over 12 tons per square foot. To avoid this heavy load on comparatively new brickwork, the mouth of the flue is to be built along with the chimney, and will project for a few feet from the side, instead of being joined into it subsequently. This will to some extent compensate for the weakening caused by the large opening.



Distance between o and x = 1 foot.

FIG. 18.

Roof Trusses.—Turning to the subject of roof trusses of iron and steel, I do not propose to enter at all into their general design, but will only refer briefly to the design of some of their details. In examining some of the designs given in text-books on building construction, some of the details being taken from actual practice, I have frequently noticed the extremely bad design of these details, some of which I propose to mention (see sketches, fig. 19). A very weak form of strut, frequently recommended in text-books, is that formed of two flat bars connected by cast- or wrought-iron distance pieces. No. 1 shows an extremely bad example, and a strut of this description is certainly not any stronger than two perfectly straight flat bars without any distance piece at all. The bends between the distance piece and the principal rafter are especially bad and absolutely unnecessary. It does not seem to have occurred to its designer that there is nothing to prevent failure in the manner shown by dotted lines in the figure, and in the text-book from which this example was taken the statement is made that the strength of this strut is dependent on the length between distance pieces, and not on its total length, which is absolutely incorrect for such a design as this.

A large wrought-iron strut of this character, but much better design, was tested some years ago in America. The strut had flat ends, and proved very weak, failing as indicated by the dotted lines in No. 2, with a stress of 16,000 lbs. per square inch, or a little over 7 tons per square inch. A properly designed strut of the same size and proportion would certainly have carried twice as much at least.

Another similar strut, No. 3, was also tested with pin ends, such as would be used in a very large roof, and failure ensued at a load of only 8,000 lbs. per square inch, or only one-fourth of what a well-designed strut of the same length, width, and flange section would carry.

No. 4 shows another weak detail. It is a fork end for a tension bar, and the legs of the fork appear to be specially designed to fail by being straightened out under load. No. 5 is somewhat better, but still not stout enough in the shoulders, in proportion to the diameter of the tie-rod. No. 6A is the end of a strut formed of two T-bars riveted together, with the ends opened out to clasp the main tie-bar and the eyes of a tension member. This is also very weak in proportion to the body of the strut. The sketch (No. 6B) alongside shows a much stronger end.

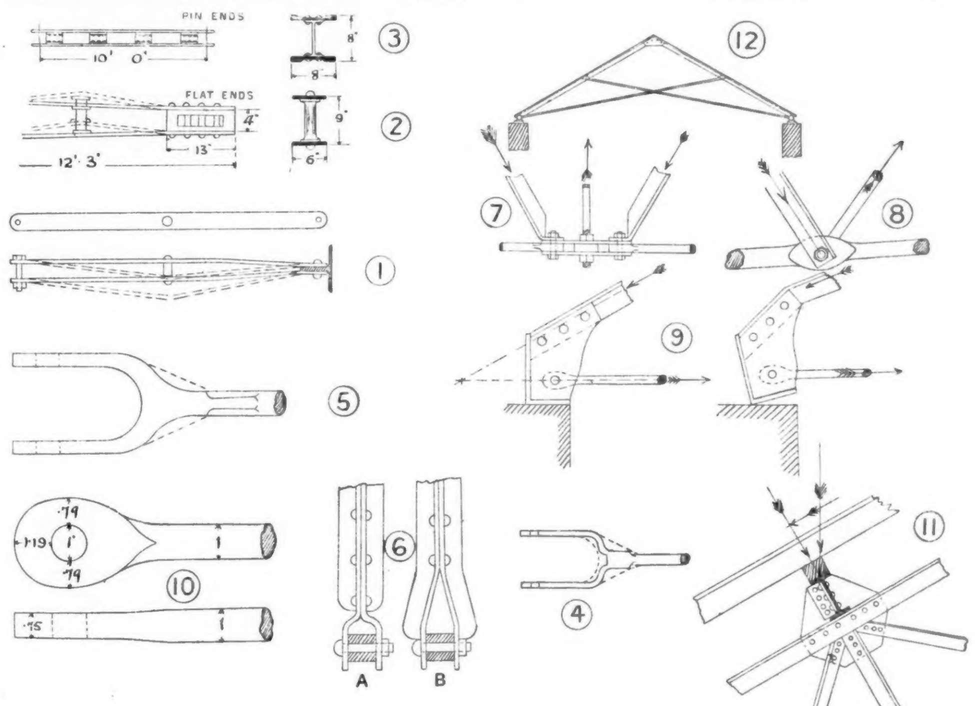


FIG. 19.—ROOF TRUSSES.

No. 7 is an instance of a very common defect. All calculations of roof trusses are based on the assumption of the intersection of the various members in certain fixed points; but this principle of intersection is most curiously neglected in practice, with the result that bending-stresses are set up in members in a most unnecessary manner. The tendency of the king-rod in the detail shown in No. 7 is to bend the plate links between the ends of the two diagonal struts, and I do not suppose that its designer ever contemplated such a condition. The main tie-rod, the struts, and the king-rod should all have met in one point. No. 8 has a defect not so easily noticed. The strut and small tie-rod are on opposite sides of the main tie-rod, with the consequence that in the particular design from which this was taken the stress from torsion would probably be nearly as serious for the main tie-rod as the direct tension upon it. The calculations accompanying this design for a roof appeared otherwise complete, but a defect of this sort destroys confidence in them.

Pins and eyes are frequently made much too weak, and I have made a sketch (No. 10), showing what would be fair proportions for wrought-iron tie-bar ends, clasped between two links, each half of the thickness of the eye-bar head. The diameter of the bar being taken as 1, with the thickness of the eye at the end three-fourths of the diameter of the bar, the pin should be equal in diameter to the tie-rod, and the width of the eye over all should be 2·58 times the diameter of the bar, giving 50 per cent. greater section through the sides of the eye than in the body of the tie-bar. The end of the eye should have a length beyond the pin hole of 1·19 diameter of bar. These proportions are based on tables given by Mr. Shaler Smith, an American engineer, who made a large number of tests to determine the proper proportions for various conditions. Unfortunately, Mr. Shaler Smith's tables of proportions are sometimes omitted, and a sketch given purporting to embody his results, which it is impossible to do in any single figure.

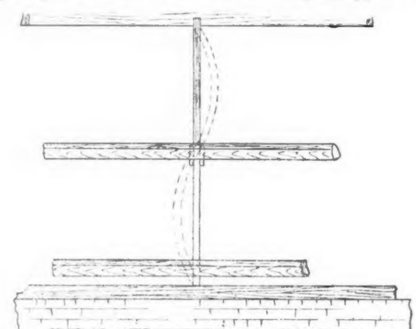
No. 9 shows another common defect, which has in one instance at least led to failure. The adjoining sketch shows what the tendency is. The axis of the rafter, the centre-line of the tie-rod, and the line of upward reaction of the wall should all have met in one point, if this overturning tendency is to be avoided.

Wrought-iron and steel roofs are most commonly made of T or angle-bar rafters and struts and round forged iron tie-bars, and while this makes a lighter looking and perhaps more pleasing roof, yet it is neither so reliable nor so economical as a roof made of angle bars throughout, riveted together with gusset-plate connections. It is a great advantage to entirely avoid any forged or machined work in all steel or iron trusses, and it is in this that a riveted truss has advantage over the more common type with forged eyebars and pin connections. The riveted roof may easily be designed so as to have no work done on the material except cutting, drilling, and riveting, and none of the material need enter the smith's fire, and no welds are necessary. The sections of the various bars, perhaps, may not be so easily proportioned to the various stresses, and a slightly heavier truss is the result; but the cost per ton of a well-designed riveted truss is much less than that of a pin-connected truss with forged eyes, &c., and, owing to the absence of welds and forgings, the riveted truss is much more reliable. These remarks are intended to apply only to roofs. In bridge trusses entirely different conditions may obtain, and the very reverse may, under certain conditions, be the better practice.

There is one matter in the calculation of the strength of roofs to which I have never seen any reference made, and that is in the case of deep rolled joist purlins on principals spaced widely. The strength of the purlin is usually calculated as though the whole load were wholly at right angles to the roof surface, but the permanent load of roof covering is a vertical load, which requires to be resolved into its components at right angles, and parallel, to the surface of the roof (No. 11, fig. 19) before we can accurately calculate the necessary dimensions of the purlin. The component parallel to the roof surface is by no means insignificant in its effect, and should certainly be taken into account. In a roof recently designed by my firm it was found that this parallel component had a greater influence on the stress in the purlin than the vertical component of permanent load and the whole wind load put together. In addition to this effect of the parallel component of the permanent load, it has also a tendency to overturn the purlin as a whole, and this is particularly the case when the roof is steep. This tendency is carefully guarded against in the case of wood roofs by the cleats spiked to the upper side of the principal rafters; but, as a rule, in iron or steel roofs it is either forgotten or neglected. No. 12 is an extremely bad design, even for a very small roof.

The usual idea in making a truss is to get rid of all transverse stress on its members and to have simple direct tension or compression on the bars. The designer of this truss has evidently had ideas contrary to this, as the tension rods are so placed that they would impose a very heavy transverse stress on the principal rafters, in addition to the direct compression on them. A worse type of iron roof could hardly be designed. The collar beam roof of wood, or a modification of it, should never be attempted in iron or steel.

Collar Beam Roof-couple.—I propose to conclude this Paper by a reference to one of the simplest types of roof



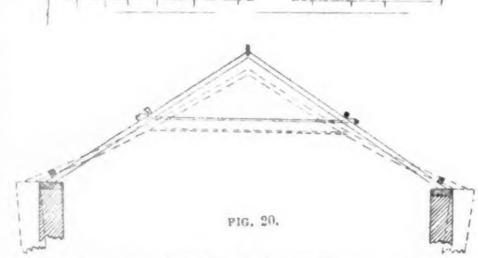


FIG. 20.

trusses of wood, and used only in small spans. I refer to the collar beam roof-couple. Owing to its being necessarily used only for small spans, I presume it has been looked upon as too insignificant to warrant any special attention being paid to the stresses upon it, as these can easily be met by moderate-sized timbers; but it may be interesting to consider this question of stress—in the principal rafter at least.

The nature of the stresses existing in the collar beam couple may be most easily appreciated by exaggerating their

effect in a sketch of two roof-couples (fig. 20), one having the principal rafter very thin and very deep, and the other having a broad and shallow rafter. In the first we can immediately conceive that the rafter would double up like a column, and in the second it is evident that it would bend like a beam. These effects are shown by dotted lines on the sketches. It is not difficult to make an approximate estimate of the effect of, say, vertical loads on a collar beam couple after we make certain preliminary assumptions. Let us assume that three purlins only are used on each principal rafter (fig. 21), one immediately over the wall, one at the end of the tie-beam, and one at the ridge, or incorporated with the ridge-board. Assume also that

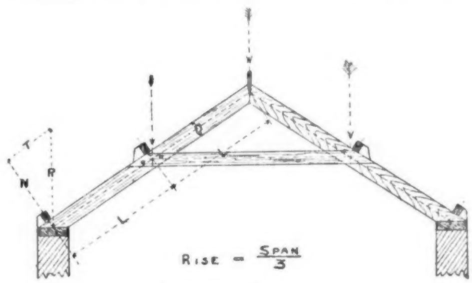


FIG. 21.

Area of principal rafter—$A = \dfrac{\frac{6NL}{D} + T}{F}$ sq. in.

D and L being in inches, N and T being in lbs., and F = lbs. per square inch safe maximum stress.

the walls are so light that they cannot act as an abutment to the outward thrust of the rafter, and that the reaction of the wall is purely vertical in consequence. Now considering the lower end of the rafter, we see that the purlin immediately over the wall has no influence on the stresses in the couple, and we may leave it out of account in what follows. The lower part of the rafter is subjected to the upward vertical reaction of the wall, which must be resolved into its components normal, and parallel, to the axis or centre line of the principal rafter. The parallel component tends to compress the rafter in the direction of its length, and the normal component tends to bend the rafter around the end of the tie-beam.

If we calculate the vertical reaction of the wall, which is simply the whole load on the roof, less the load resting on the purlins immediately over the wall (so far as concerns our present inquiry), then the triangle of forces immediately gives us the values of the parallel and normal components. From these the maximum stress in the rafter can be immediately calculated when we know the size of the rafter, or we can calculate the size of the rafter when we fix upon the maximum stress.

Let the parallel component $= T$
" " normal " $= N$
" " breadth of rafter $= B$
" " depth " $= D$
(then Area $= A = BD$)
" F = maximum stress per square inch allowable
$\left(\begin{array}{l} = \pm f_b \text{ (from bending)} \\ + f_d \text{ (from direct thrust)} \end{array}\right)$

$$\pm f_b \text{ from bending} = \pm \frac{6 \times \text{bending moment}}{BD^2},$$

$$f_d \text{ from direct thrust} = \frac{\text{direct load}}{BD} = \frac{T}{BD},$$

$$F = \pm f_b + f_d = \pm \frac{6 \times \text{bending moment}}{BD^2} + \frac{\text{direct load}}{BD},$$

the bending moment $= N \times L$, where L = length of principal rafter from tie-beam to end.

Then $$F = \pm \frac{6NL}{BD^2} + \frac{T}{BD} = \pm \frac{6NL}{AD} + \frac{T}{A}.$$

From this $$A = \text{sectional area of rafter} = \frac{\pm \frac{6NL}{D} + T}{F}.$$

In the foregoing formula N and T should be taken in lbs. when F is taken in lbs. per square inch, and D must be taken in inches, A being sectional area in square inches; L must also be taken in inches to correspond.

I need hardly say that I have assumed that sufficient breadth will be given to the rafter to prevent it yielding, as a column under compression. The calculations also take no account of the great weakening caused by notching the collar beam into the rafter, or of the loss caused by making bolt holes, &c. These require to be carefully allowed for, and the area A given by the formula is the least area of an uncut rectangular section immediately at the junction of the collar beam with the rafter.

In conclusion I may remark that in making calculations of stress, and determining theoretically the necessary scantlings to resist stress, they should be very carefully and conscientiously made; but at the same time it should be borne in mind that in very many cases, indeed nearly every case, however carefully we may make our assumptions and carry through our calculations, the results are, owing to our ignorance, really very rough approximations. The best practice is based upon the comparison of our calculations with such *failures* as may from time to time occur. The comparison of our calculations with work which stands proves very little, and indeed I believe that many structures stand because they have never had the loads upon them for which they were designed primarily.

PARLIAMENTARY.

THE LONDON BUILDING ACT 1894.

Dwelling-houses on Low-lying Land.

The following regulations have been made by the London County Council under Section 123 of the London Building Act 1894 (57 & 58 Vict., cap. ccxiii.):—

Every person who shall be desirous of erecting or adapting any building to be used wholly or in part as a dwelling-house on any land in the county of London of which the surface is below the level of Trinity high-water mark, and which is so situate as not to admit of being drained by gravitation into an existing sewer of the Council, shall first make a written application for a licence. Such application shall be addressed to the Clerk of the Council.

Such application shall contain a statement as to the nature and extent of the interest of the applicant in the building or buildings proposed to be erected or adapted, and be accompanied by a plan and section of the lowest floor of such building or buildings and the curtilages thereof to a scale of ⅛th of an inch to a foot, and by a block plan to a scale of not less than $\frac{1}{2500}$ (which may be on a sheet or sheets of the Ordnance Survey, or may be drawn on tracing linen), showing the position of such building or buildings and the local sewer into which it is proposed to drain such building or buildings, and the connection of such local sewer with an existing sewer of the Council.

Such plans and sections shall be accompanied by a description of the materials to be used in the construction of such building or buildings, and shall be coloured in accordance therewith. The points of the compass shall be marked on the block plan.

The position and course of the drainage system pro-

posed to be adopted for the disposal of sewage and rain water, and its connection with the local sewer or an existing sewer of the Council, shall be clearly shown on the plans and sections, and the diameter and inclination of the drain pipes shall be figured thereon.

The plan and section shall also indicate in figures the level above or below ordnance datum at which it is proposed to construct the floor of the lowest rooms.

The decision given by the Chief Engineer of the Council upon such application shall be reported to the Building Act Committee, and the Committee shall report it to the Council; and thereupon, if it is to the effect that the erection or adaptation may not be permitted, the Clerk of the Council shall by letter inform the applicant that the Council, acting upon the decision of the engineer, has refused permission. If it is to the effect that the erection or adaptation may be permitted, a licence under the seal of the Council embodying the conditions of the engineer's decision shall be issued to the applicant.

The seal of the London County Council was hereunto affixed on the 3rd day of April, 1895. (Seal)

H. De la Hooke, *Clerk of the Council.*

Signed on behalf of the Tribunal of Appeal in token of their concurrence in the foregoing regulations.

Arthur Cates, *Chairman of the Tribunal.*

8th April 1895.

The following regulation has been made by the Council under Section 122 of the London Building Act 1894:—

It shall not be lawful to place the underside of the lowest floor of any permitted building at such a level as will render it liable to flooding, and every permitted building shall be efficiently and properly drained to the satisfaction of the engineer for the time being of the Council, either into a local sewer or into a main sewer of the Council.

LEGAL.

The London Building Act 1894.

WATKINS *v.* CROW [p. 320], and REDHOUSE *v.* CROW.

In the *Law Journal* of the 6th April Mr. Arthur Crow [*F.*] reports the first decision on the party-wall sections of the London Building Act 1894 as follows:—

In the case of *Watkins* v. *Crow* the District Surveyor, by "notice of objection" served under section 150 of the new Act, sought to compel the owner of No. 1, Church Street, Minories, to bring the party-wall next No. 3 into conformity therewith. The facts disclosed at that hearing were, briefly, these: As the result of a fire in November 1894 the warehouse No. 3 was almost entirely down. No. 1 was slightly damaged, and the party-wall between them had been pulled down, under a dangerous-structure notice, to the extent of one-third of its superficial area. At the time that case was heard the owner of No. 1 had given notice, under section 145, of his intention to reinstate the party-wall in question. The owner of No. 3 appeared to have taken no steps towards rebuilding his warehouse. It was admitted that, so far as regarded No. 1, the wall need not be altered, because, since No. 1 had not been destroyed for more than half its cubical extent, the reinstatement thereof would not be "a new building," as defined by section 5 (6); and it was also admitted that, since the party-wall itself had not been destroyed to the extent of one-half of its superficial area, it could not be dealt with under section 208. But it was contended on behalf of the District Surveyor that, as No. 3 had been destroyed for more than half its cubical extent, and the reinstatement thereof would accordingly be deemed to be the erection of a "new building," therefore every part of such building, including this party-wall, must be made to comply with the London Building Act 1894. It was held by Mr. Haden Corser, after consideration, that, since no notice had at that time been given for the rebuilding of No. 3, and the objection was given on the notice of the owner of No. 1, the party-wall must be considered in its relation to No. 1 only, and that, as No. 1 had not been damaged sufficiently to bring it within the definition of a "new building" under section 5 (6), and the party-wall had not been taken down or destroyed to the extent of one-half, so as to bring it within the scope of section 208, the wall could be reinstated without regard to the requirements of the new Act.

Soon after this decision Mr. Samuel Redhouse, builder, of Stotfold, Baldock, Herts, gave the District Surveyor notice of his intention to rebuild No. 3, whereupon the Surveyor served on Mr. Redhouse a "notice of objection" with regard (*inter alia*) to this party-wall; and the objection came on to be heard on the 23rd March, before Mr. Dickinson, at the Thames Police Court. Mr. T. Seager Berry, of the Solicitors' Department of the London County Council, appeared for the District Surveyor. A preliminary objection was taken by Mr. Cobban, solicitor, on behalf of Mr. Redhouse, on the ground that the party-wall was the same wall which had formed the subject of the former proceedings, when Mr. Haden Corser had decided that the District Surveyor's notice must be disallowed. Mr. Berry contended that the circumstances had entirely changed, and that they were now dealing with a building which came within the definition of a "new building," and thus a case had arisen such as Mr. Haden Corser had expressly declined to give an opinion on when the possibility of its arising was suggested to him, and it was under these new and different circumstances that the District Surveyor now asked that this party-wall should be amended. In reply to a question from the learned magistrate Mr. Cobban contended that it was immaterial whether No. 3, Church Street, were a "new building" as defined by section 5 (6) or not, but that the question really was as to how far this party-wall had been taken down; if more than half, then it must be rebuilt under section 208; if less than half, it need not be altered. He submitted, further, that both the buildings, No. 1 and No. 3, might be entirely destroyed, and yet if half the party-wall remained intact, even then the wall need not be altered. The magistrate said this was a very strong suggestion to make, and Mr. Berry urged that it was going back on previous legislation, for section 10 of the Act of 1855 clearly laid down that when an old building was more than half destroyed, the remainder, so far as not in conformity with the then new law, had to be pulled down, and the object of section 208 was to supplement section 5 (6), which virtually re-enacted section 10 of the Act of 1855, and not to in any way derogate from such section, and that section 208 referred to the case of a party or external wall *per se*, and intended that, although a building itself might not be half destroyed, yet any one wall of it if destroyed or taken down to the extent of half should be, not of necessity pulled down, but brought into conformity with the new law as regards the whole of such wall. The magistrate, after carefully considering the sections quoted, upheld Mr. Cobban's contention, and decided that section 208, which dealt with party-walls (and external walls), must govern the case, and that notwithstanding the fact that No. 3 was destroyed for more than half its cubical extent, yet, as half the party-wall had not been destroyed, the new law did not require that the wall should be made conformable thereto, and said that he ruled that section 208 ousted the provisions of section 5 (6) as to party and external walls. The District Surveyor's notice was accordingly disallowed. The magistrate expressed his willingness to state a case if asked, and declined to grant costs, saying that he considered it was a proper case to have been taken up by the District Surveyor in the public interest.